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THUSIS IN THE VALLEY OF THE RHINE, WHERE THE ALBULA-ENGADIN ROAD BEGINS.



THE GREAT VIADUCT OVER THE LANDWASSER, NEAR FILISUR.
THE ALBULA-ENGADIN RAILWAY.

THE HIGHEST TUNNEL IN EUROPE.*

By the London Correspondent of the SCIENTIFIC AMERICAN.

DURING a recent visit to Switzerland the writer traveled over the new Albula-Engadin Railway, which has just been opened as far as Samaden.

This new line is chiefly remarkable for the Albula tunnel, which can boast of being the highest tunnel in Europe.

In the following table the lengths and heights of the great European tunnels are compared:

Tunnel.	Highest Point. Meters.	Length. Meters.
Albula	1,823	5,866
Arlberg	1,311	10,250
Mont Cenis	1,295	12,849
St. Gothard	1,155	14,984
Semmering	898	1,430
Simplon	704	19,770

The Albula-Engadin Railway will soon reach St. Moritz, the highest village in the Engadine.

It is 6,033 feet above sea-level, and is famous as a health resort for consumptives and is frequented by healthy folk who spend their days in skating and tobogganing and their nights in dancing and other entertainments.



THE RAILWAY ABOVE BERGÜN, SHOWING THE FIRST, SECOND AND THIRD ALBULA VIADUCTS.

THE ALBULA-ENGADIN RAILWAY.

The Albula-Engadin Railway commences at Thusis in the Rhine Valley. The narrow-gauge Rhetian line from Coire to Thusis was opened in 1896, and since then Thusis has been the chief starting point for the Engadin diligences.

From Thusis travelers usually proceeded to St. Moritz by the Tuber, and to Pontresina by the Albula. The days of the horse diligence are, however, numbered, and the railways and motor diligences will soon wipe it off the face of the "playground of Europe."

The new railway was commenced in 1898. It is a narrow-gauge line, and when opened to St. Moritz will be 40 miles in length. From Thusis the line traverses the Schyll Pass to Tiefenkastell. Of this eight miles no less than one-third is in tunnel. There are fourteen tunnels and sixteen viaducts, with a total span of 4,163 feet. At Tiefenkastell the line enters the open Albula Valley. Near Filisur is the great bridge (shown in one of our illustrations) over the Landwasser.

This is 196 feet high and 492 feet long, and consists of six spans.

Between here and Bergün there are more tunnels, and beyond Bergün the line ascends in loops and tunnels which remind one of the St. Gothard and the Brenner railways.

At Alp Preda—5,898 feet—the train enters the longest tunnel on the route, known as the Albula tunnel.

This is $3\frac{1}{2}$ miles long, 15 feet wide, and $16\frac{1}{2}$ feet in height. This tunnel cannot compare with the Arlberg, Mont Cenis, St. Gothard, or Simplon in length, but it is at a higher level than any of these, its highest point being 5,987 feet above the sea-level.

The tunnel passes the dividing ridge between the waters of the Rhine and the Danube, and is said to be the highest railway track in Europe. The Albula tunnel has cost some six million francs and was some four and a half years in construction.

The track in the tunnel ascends with a gradient of 1 in 10 to its highest point, and descends with a gradient of 1 in 50 to its eastern entrance at Spinas. Hence the line runs to Bevers, and reaches its present terminus at Samaden. The Albula-Engadin Railway will eventually terminate in a bay of the St. Moritz Lake below the Hotel Belvedere, and the Samaden-St. Moritz extension will be opened before many months are past.

Needless to say, the new railway runs through some magnificent scenery and affords splendid views, though whether those who are in the habit of visiting St. Moritz will appreciate its construction and the inevitable influx of the "tripper" element may be doubted.

METHODS FOR WATERPROOFING LEATHER.

DIFFERENT processes are used for this purpose. Vegetable and organic fats and waxes are employed. Dry-

ing oils should be avoided, for they render the leather hard and brittle, and the employment of glycerine and mineral oils is not to be recommended.

The most important agent for rendering leather impermeable is degrass combined with tallow. The following mixtures may, for example, be made in summer: 60 parts of tallow with 40 parts of degrass; in winter a less proportion of tallow is made use of. In places where cod-liver oil is cheap, 1 part of this may be mixed with equal quantities of tallow and degrass. Numerous methods have been tested at the Gewerbeblatt Laboratory in Wurtemberg, with the result of recommending the two following processes: (1) The mixture known under the name of Jennings and composed of equal quantities of soap, zinc, and linseed oil, dissolved at 106 deg. C., and the leather immersed in the solution. The zinc soap is obtained by taking 6 parts of white soap, dissolved in 60 parts of boiling water, and 6 parts of zinc added and shaken. The zinc soap is precipitated and rises to the surface; on cooling, it forms a solid cake, which is purified by redissolving in boiling water. (2) The Crudeaux method, which consists in dissolving 30 grammes of caoutchouc in half a liter of oil of turpentine. The leather is treated with this solution for eight days, until it will absorb no more.

These are not the only methods employed; there are various others, but most of them are quite complicated.—Translated from La Revue de Chimie Industrielle.

RECENT ELECTRICAL RESEARCHES BY BERTHELOT.

RELATION BETWEEN THE INTENSITY OF THE VOLTAIC CURRENT AND THE MANIFESTATION OF THE ELECTROLYTIC OUTPUT.*

My previous experiments on this relation have been on batteries whose electromotive force is considerable and very much exceeds that required for the electrolysis of acidulated water. It has, therefore, appeared to me desirable to undertake some experiments with batteries whose electromotive force surpasses but slightly the counter-electromotive force of the volt-meter. I selected as a fundamental element one in which the interior porous vessel contained 50 centimeters of soda ($\text{NaOH} = 5$), to which a fifth of its volume of pyrogallol ($\text{C}_6\text{H}_3\text{O}_2 = 5$) had been added; while the exterior vessel contained 250 cubic centimeters of sodium chloride ($\text{NaCl} = 5$), to which a fifth of its volume of oxygenated water ($\text{H}_2\text{O}_2 = 5$) had been added.

I first operated with two elements and measured the electromotive force, the intensity, and the electrolytic action; then I repeated the same experiments with only one element; all at a temperature of about 25 deg. C. 11h. 24m. Electromotive force: $0.86 \text{ volt} \times 2 = 1.72 \text{ volts}$. 11h. 25m. The current was closed on an exterior resistance $R = 54,000 \text{ ohms}$. 11h. 26m. Deviation in divisions of the scale: $n = 53.5 \text{ d.}$

This deviation, measured from minute to minute, remained quite constant. At 11h. 30m. the electromotive force was measured: $0.85 \text{ volt} \times 2 = 1.70 \text{ volts}$. The circuit was opened and then closed on the volt-meter. Voltmeter with dilute sulphuric acid: 0.76 m. Nothing. Pressure reduced to 0.008 m.: electrolysis slow, but distinct, at the end of two minutes.

Voltmeter with pyrogallol: 0.76 m. Electrolysis considerable, with disengagement of hydrogen. The electromotive force then measured: $0.85 \text{ volt} \times 2 = 1.70 \text{ volts}$.

It will be seen that this battery with regard to intensity remained essentially constant during the whole of the experiments. According to the deviation of the galvanometer and the electromotive force of the battery, the interior resistance of the latter was $\rho = 1.70 \times 2,000,000$

53.5

to the conclusion: $i = 0.00001 \text{ ampere}$; disengagement of hydrogen per minute in the voltmeter: 0.000006 milligramme; for a voltage calculated at $1.70 - 1.60 = 0.1 \text{ volt}$.

The real voltage is a little stronger, the electromotive force necessary for decomposing acidulated water being comprised in reality between 1.5 volts and 1.6 volts; consequently, the calculated disengagement of hydrogen is comprised between 0.000012 and 0.000006 milligramme.

It may be remarked that the limit found by experiment in the voltmeter with two Daniell cells under a pressure of 0.005 m. corresponds to 0.000014 milligramme per minute for a very distinct disengagement, and to a value of nearly half less, 0.000007 milligramme, for the point where the phenomenon begins to be visible.

According to these indications, no disengagement would be observed under the pressure of 0.76 m. (disengagement limit 0.00037 mg.); but a feeble and slow disengagement of hydrogen would be observed at reduced pressure; this is exactly what the experiment has shown.

In operating the electrolysis with a voltmeter with sulphuric acid containing pyrogallol, the calculated voltage will be $1.7 - 0.8 = 0.9 \text{ volt}$; $i = 0.00009 \text{ ampere}$ corresponds to a disengagement of hydrogen of 0.000054 mg. per minute; the limit of a very distinct disengagement of hydrogen being 0.000087, and that of a slow disengagement 0.000043. We are therefore well within the limits of a manifest electrolysis. Experiment and calculation agree perfectly.

II. I now present experiments made with a single element similar to those with the preceding battery. 11h. 33m. E (electromotive force) = 0.87 volt. 11h. 34m. Current closed. Exterior resistance, $R = 54,000 \text{ ohms}$; 11h. 35m. $n = 27.3 \text{ div.}$ This deviation measured from minute to minute remains identical up to 11h. 39m. Then $E = 0.82 \text{ volt}$. Current open and closed again, E rose to 0.87 volt; after the tests of electrolysis, 0.83 volt.

I will adopt for calculation this value 0.83 volt. From this is deduced: $\frac{0.83}{27.3} \times 2,000,000 - 54,000 = 6,080 \text{ ohms}$

$= \rho$ $\frac{9,550}{2} = 4,775$, which, corresponds to two elements united, mentioned above.

We need not concern ourselves this time with the electrolysis of the dilute acid alone, E being insufficient.

Besides the experiment has furnished nothing, even at reduced pressure. But, for the voltmeter with pyrogallol, $i = \frac{0.83 - 0.80}{6,080} = 0.0000049 \text{ ampere}$ equivalent to a disengagement of hydrogen of 0.0000030 mg., a quantity slightly inferior to the limit of a very distinct flow or 0.0000036 mg. under reduced pressure, but superior to the extreme limit 0.0000018 milligramme.

In fact, the experiments in electrolysis by means of the voltmeter containing pyrogallol have furnished nothing under the pressure of 0.76 m.; while under a pressure reduced to 0.007 m., a slow disengagement of gaseous bubbles has been produced. Calculation and observation are therefore in perfect accord, even for these extreme limits, answering to an excess of electromotive force of 0.03 volt only.

I remark also that this limit is sufficient for determining a visible electrolysis, which furnishes a new

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proof of the exactness of the measures employed in the calculation of the phenomena.

MANIFEST ELECTROLYTIC ACTIONS DEVELOPED BY BATTERIES CONSTITUTED BY THE REACTION OF TWO LIQUIDS, ONE CONTAINING AN ACID, THE OTHER AN ALKALI.

The discovery of the precise conditions which determine the limit of visibility of electrolytic reactions has led me to take up from this viewpoint the study of batteries founded on the combination of an acid and a base in dilute solutions. I have succeeded in ascertaining that these batteries are really capable of producing visible and continuous electrolyses. The following is a summary of my new experiments.

1. Chlorhydric acid and soda: $\text{HCl} + \text{NaOH}$.
(a) Six elements with porous vessels. $E = 2.40$ volts initial; 1.32 and 1.58 volts final. The current was made to act on a voltmeter containing dilute sulphuric acid, to which pyrogallol had been added, under a pressure of 0.002 m. There was a continuous and distinct, though slight disengagement of hydrogen. The intensity was measured at the same time by placing the galvanometer in the circuit without any other resistance than that of the instrument (205 ohms). Thus

was found directly: $i = \frac{E}{R} = \frac{1.32}{205} = 0.000003$ ampere, which corresponds, according to the calculation, to a disengagement of hydrogen per minute equal to 0.0000018 mg.

The limit of sensibility, according to my preliminary researches, under a pressure of 0.005 m., that is to say, a little stronger, was comprised between 0.000003 and 0.0000015 mg. The experiments are therefore concordant.

(b) Another similar experiment made under tenfold pressure (0.018 m.) has furnished a negative result, that is to say, non-visible, in conformity with what had been anticipated.

2. Sulphuric acid and soda.—According to two experiments, six elements of this kind, without porous vessels, disengaged hydrogen continuously in a voltmeter with pyrogallol, under a pressure of 0.005 m.; result in conformity with the limit deduced from the measures of intensity.

3. Lactic acid and soda: $\text{C}_2\text{H}_3\text{O}_2 + \text{NaOH}$.

(a) Six elements with porous vessels. E initial 2.6 volts, final 1.86 volts. The current was closed on the voltmeter with pyrogallol and the galvanometer ($R = 205$ ohms) united. Immediately: deviation 45 div.; pressure in the voltmeter 0.005 m. Electrolysis very distinct. The deviation fell rapidly to 33 div.; the gaseous disengagement, under pressure of 0.005 m., became less active. $i = 0.0000165$ ampere, corresponding to hydrogen per minute, 0.000008 m.; value exceeding the limit 0.000003. At this moment $E = 1.86$ volt. The current was again closed on an exterior resistance of 54,000 ohms. After 5 minutes: deviation, 18.4 div. $E = 1.6$ volt. i , calculated, corresponds to 0.000004 mg. of hydrogen per minute. Visible electrolysis. The simultaneous decrease of intensity and of electrolytic action was observed to the very limit of visibility.

(b) Twelve elements. Electric force in the beginning of experiment 4.4 volts; at the end 3.0 volts. Electrolysis distinct, continuous, but feeble in the voltmeter with pyrogallol; pressure 8.005 m. The disengagement was not visible under the pressure of 0.760 m.

The intensity has been determined by two processes: in one, intensity measured without voltmeter with exterior resistance = 54,000 ohms. Deviation after 5 minutes: 16.5 div. Electromotive force = 3.0. Calculation for $E = 3.0$ volts — 0.8 volt; $i = 0.0000067$ ampere; calculated flow of hydrogen per minute 0.000004 mg.; figure higher than the limit 0.000003.

In the other: intensity measured directly with galvanometer interposed without any other resistance in the circuit: $i = 0.0000062$ amp. (direct measure). Calculated flow of hydrogen per minute: 0.0000037 mg.

The two values agree, and they assure a disengagement of hydrogen near the limit with the voltmeter with pyrogallol, under reduced pressure, which the experiment has verified. Moreover, the comparison of the two experiments, one executed with twelve elements and the other with six elements, shows that the final intensity has not been reached or the flow of hydrogen by doubling the number of elements. This is an important observation. The possibility of such a maximum may be conjectured according to the calculation of i , ρ and E ; but it is interesting to ascertain its reality by experiment. The fact will be confirmed on other similar batteries.

4. Oxalic acid and soda: $\text{C}_2\text{H}_2\text{O}_4 + \text{NaOH}$.

(a) Six elements with porous vessels. E initial 2.64 volts; final, 2.4 volts. Current closed on the voltmeter (with pyrogallol) and the galvanometer ($R = 205$ ohms): Deviation 33 div. $i = 0.0000135$ amp. corresponds to hydrogen per minute 0.000008 mg. Electrolysis distinct and continuous under a pressure of 0.006 m.

(b) Another experiment with the same battery. $E = 2.4$ volts; final, 1.8 volts. $R = 54,000$ ohms, deviation after 5 minutes 19 div.: $\rho = 135,500$; i , calculated 1.8 — 0.8

$= 0.0000074$ amp. corresponds to hydrogen per minute 0.0000044 mg.

Electrolysis with the galvanometer has been tried, the resistance in the circuit being 205 ohms. Deviation 12 div. Direct measure: $i = 0.000006$; corresponds with hydrogen per minute 0.0000036 mg. Electrolysis distinct, feeble, and continuous.

(c) Twelve elements. E initial 4.4 volts. Current closed on the voltmeter (with pyrogallol and galvanometer united): Deviation 21 div. $i = 0.000011$ amp. direct measure. Hydrogen per minute 0.0000066 mg. Electrolysis distinct and continuous, results only slightly different from those observed with only six elements. This has given me the idea of diminishing their number.

(d) Four elements. The current closed on the galvanometer and the voltmeter with pyrogallol. Pressure 0.006 m. Deviation 21 div. Electrolysis distinct and continuous. $i = 0.000011$ amp.; direct measure corresponds to hydrogen per minute 0.0000066 mg. Results about the same as with twelve elements.

(e) Two elements. Deviation 3 div. i , directly measured, = 0.0000015 amp. No electrolysis.

(f) Three elements. Deviation 12 div. i , directly measured, = 0.000006 amp.; corresponds to hydrogen per minute 0.0000036 mg. Distinct and continuous electrolysis. $E = 1.41$ volts = 0.47×3 .

The limit of electrolytic aptitude is here clearly indicated between two and three elements.

5. Acetic acid and soda: $\text{C}_2\text{H}_3\text{O}_2 + \text{NaOH}$.

(a) Six elements. Porous vessels: at 5h. 11m. $E = 2.22$ volts; increases; at 5h. 26m. 2.62 volts or 0.42×6 initial; E final = 2.34 volts. Current closed on galvanometer and voltmeter with pyrogallol. Pressure: 0.002 m. Distinct and continuous electrolysis. Deviation 22 div. i , direct measure, = 0.000014 ampere, corresponds to hydrogen per minute 0.0000084 mg.

(b) Four elements. Deviation, 10 div. Feebler electrolysis. $i = 0.000005$ amp., hydrogen calculated per minute = 0.000003 mg.

(c) Three elements. Deviation, 4 div., hydrogen per minute calculated, 0.0000001 mg.; electrolysis, not visible.

(d) One element. E initial, 2.34 volts; E final, 1.8 volts. Deviation: 16.5 div. after 5 minutes; $R = 1.8 - 0.8$

$= 54,000$ ohms, $\rho = 164,000$ ohms; $i = \frac{1.8}{164,000} = 0.0000061$ amp.; hydrogen calculated per minute 0.0000036 mg. Electrolysis visible under reduced pressure.

6. Chlorhydric acid and ammonia: $\text{HCl} + \text{AzH}_3$.

(a) Six elements, porous vessels. E initial rises from 1.68 to 1.90 volts; final 1.32 volts. $R = 54,000$ ohms. Deviation after 5 minutes 4 div. Calculation of $i = 0.000002$ amp. hydrogen per minute 0.0000012 mg. No electrolysis visible under a pressure of 0.003 m.

(b) Six elements. $E = 2.02$ volts. Immediately after the voltmeter with pyrogallol and the galvanometer were interposed. Pressure, 0.003 m. Deviation, 12 div.: $i = 0.000006$ amp.; hydrogen per minute, 0.0000036 mg. Distinct though slight electrolysis.

(c) Four elements. Same arrangement. $E = 0.98$ volt. Deviation, 5.5 div.; hydrogen per minute 0.0000016 mg. Electrolysis visible to the limit.

(d) Three elements. Nothing.

According to these experiments, batteries formed by the combination of an acid and a base possess a definite electromotive force, developing a continuous current of measurable intensity, and are capable of electrolyzing acidulated water, and with the addition of pyrogallol in a continuous and visible manner, under reduced pressure, disengaging hydrogen.

NEW EXPERIMENTS ON THE LIMIT OF INTENSITY OF THE CURRENT OF A BATTERY CORRESPONDING TO THE MANIFESTATION OF AN EXTERIOR ELECTROLYTIC OUTPUT APPARENT IN A VOLTMETER.

I have determined these limits with two different voltmeters: one containing only dilute sulphuric acid with Wollaston electrodes, a voltmeter in which the production of a continuous visible reaction (disengagement of hydrogen and oxygen) requires an electromotive force whose minimum is comprised between 1.5 and 1.6 volts; the other containing the same dilute acid with the addition of pyrogallol, a voltmeter in which hydrogen alone is disengaged continuously under the influence of an electromotive force, whose minimum is nearly 0.8 volt.

I have varied the following conditions successively: exterior pressure; concentration of acid; concentration of additional pyrogallol; excess of electromotive force of the battery over the minimum electromotive force necessary to determine a continuous electrolysis.

The exterior resistance employed to attain the limit near which the electric output ceases to be manifested has varied from very small values to 1,000,000 ohms. This resistance, as well as the electromotive force, being measured according to known formulas, allows of calculating the intensity i , and of deducing from this the weight of hydrogen h disengaged in one minute. The determinations of this limit are, however, only approximate, as every measure relating to the commencement of a phenomenon must be.

1. Sulphuric acid alone in the voltmeter.

1. Variable exterior pressure in the voltmeter. Two Daniell cells. Temperature 20 deg. I shall call determining electromotive force the excess of the electromotive force of the battery over that which determines the reaction in the voltmeter; or, for the battery employed, 2.24 volts — 1.60 volts = 0.64 volt. R is the exterior resistance. The liquid of the voltmeter contained 106 grammes of sulphuric acid per liter.

Electrolysis.			
M. Ohms.	Resistance.	Intensity.	Hydrogen per minute.
	Dist. Dist.	Dist. Dist.	
Pressure 0.760 2,000	$i = 0.00008$ amp.*	3,000 ohms.	0.0000037
	$h = 0.00019$ mg.		0.000013
Pressure 0.250 10,000	$i = 0.00006$ amp.*	30,000 ohms.	0.0000032
	$h = 0.000087$ mg.*		0.000019
Pressure 0.050 30,000	$i = 0.00004$ amp.*	30,000 ohms.	0.000002
	$h = 0.000019$ mg.		0.000015
Pressure 0.005 30,000	$i = 0.000021$ amp.*	40,000 ohms.	0.000013
	$h = 0.000014$ mg.		0.000010

* Gas at the two poles ($\text{H}_2 + \text{O}$). + Gas especially at the pole + (H_2).

The limit of pressure corresponds to an exterior resistance which is the greater as the pressure is less. The extent of the variations of resistance has been from 1 to 15; that of the variations of pressure from 1 to 152, ten times greater.

2. Sulphuric acid alone. Variable concentration. Pressure 0.760 m. $t = 31$ deg. 2 Daniells.

Electrolysis.			
g.	Exterior resistance.	Intensity.	Hydrogen per minute.
	Ohms.	Amp.	Mg.
Acid containing 10 g. per liter 307 g.	2,000*	0.000032	0.000019
	3,000	0.000021	0.000013
Acid containing 10 g. per liter 106 g.	2,000	0.00008	0.000019
	3,000	0.00006	0.000013
Acid containing 10 g. per liter 1 g.	1,000*	0.00004	0.000008
	3,000*	0.000021	0.000013

* Gas at the two poles ($\text{H}_2 + \text{O}$). + Gas especially at the pole + (H_2).

It will be seen that the concentration between 200 and 100 grammes of acid has only a slight influence on

the limits. In a very dilute liquid, however, the disengagement ceases with a considerably feeble resistance. This depends on a change in the cohesion of the liquid rather than in its conductivity. In fact, the specific resistances of the solutions of sulphuric acid deduced from the calculations of the conductivity measured by M. Bouty, would correspond at about 18 or 20 deg. C. to the following values: $r = 2.48$ ohms for the solution of 1 g. per liter. $r = 2.64$ ohms for the solution of 94 g. They vary rapidly with the temperature. All these resistances are besides almost negligible as compared with the exterior resistances brought into play in the present experiments.

Here follows another experiment, executed by electrolyzing a solution of soda (20 grammes $\text{NaOH} = 1$) in the voltmeter, under the pressure of 0.760 m. Two Daniells were used in the operation.

Electrolysis.			
Resistance.	Dist. Dist.	Slow.	Traces.
Intensity.	200 ohms.	1,000 ohms.	5,000 ohms.
Hydrogen per minute.	0.00012 amp.	0.0006 amp.	0.00012 amp.
	0.0008 mg.	0.0004 mg.	0.00008 mg.

The specific resistance of a solution of soda containing 25 grammes to the liter according to the numbers of Kohlrausch would answer to 9.3 ohms at 18 deg. Here the increase of specific resistance corresponds with the lowering of the limit.

3. Sulphuric acid alone. Variable determining electromotive force. I have varied this determining electromotive force E from that which corresponds with 6 Daniells (6.6 volts) to 2 Daniells (2.2 volts); or E from 5 volts to 0.6 volt.

During experiments made with elements of a battery different from Daniells, E has been reduced to a value of about 0.1 volt. I now give only results obtained with Daniell elements under two different pressures.

1. Under the normal pressure 0.760 m.:

Electrolysis.			
	Exterior resistance.	Limit of intensity.	Hydrogen per minute.
	Ohms.	Amp.	Mg.
2 Daniells	distinct	2,000	0.00000
$E = 0.6$ volt	slow	3,000	0.000020
	slow	4,000	to
6 Daniells	distinct	30,000	0.00005
$E = 5.0$ volts	slow	30,000	0.00025
	slow	30,000	0.00017

2. Under the pressure 0.008 m.:

Electrolysis.			
	Exterior resistance.	Limit of intensity.	Hydrogen per minute.
	Ohms.	Amp.	Mg.
2 Daniells	distinct	30,000	0.000020
$E = 0.6$ volt	slow	30,000	0.000012
6 Daniells	distinct	30,000	0.000012
$E = 5.0$ volts	slow	500,000	0.000010
	slow	500,000	0.000006

It may be regarded that the limit of intensity under a given pressure is essentially the same; that is independent of the determining electromotive force. This result is besides in conformity with the theory.

II. Dilute sulphuric acid with the addition of pyrogallol.

Here we have experiments executed with dilute sulphuric acid to which pyrogallol has been added in the voltmeter. One Daniell was used in the operation, the electromotive force of this element being sufficient to electrolyze the water.

1. Variable pressure. Sulphuric acid 106 g. per liter, containing besides pyrogallol ($\text{C}_2\text{H}_3\text{O}_2$: 10 g.); $t = 20$ deg.

Electrolysis.			
	Exterior resistance.	Intensity i .	Hydrogen per minute.
	Ohms.	Amp.	Mg.
Pressure 0.760 m.	distinct	2,000	0.00006
	slow	4,000	0.00006
	slow	5,000	to
Pressure 0.250 m.	distinct	8,000	0.00004
	slow	10,000	0.000032
Pressure 0.050 m.	distinct	15,000	0.00002
	slow	20,000	0.000016
Pressure 0.005 m.	distinct	40,000	0.000011
	slow	30,000	0.000006
	slow	30,000	0.000004
	slow	80,000	0.000008

According to these numbers, the limit of pressure for which the gaseous disengagement is distinct corresponds to an exterior resistance which is the more considerable as the pressure is less; it is the same with sulphuric acid without pyrogallol. The intensity limits with pyrogallol are about half of those observed without pyrogallol; conformably to the relation of the electromotive force necessary, or $2.2 - 1.6 = 0.6$ volt, with the voltmeter with acid alone operated by 2 Daniells, and $1.1 - 0.8 = 0.3$ volt with the voltmeter with pyrogallol, operated by a single Daniell.

2. Sulphuric acid and pyrogallol. Variable concentration. Under the pressure 0.76 m. 1 Daniell; $t = 21$ deg.

(a) Sulphuric acid: 307 g. per liter.

Electrolysis.			
g.	Exterior resistance.	Intensity i .	Hydrogen per minute.
	Ohms.	Amp.	Mg.
Pyrogallol 50	distinct	4,000	0.00004
50	slow	10,000	0.00002
50	traces	20,000	0.00001
Pyrogallol 10	distinct	4,000	0.00004
10	slow	10,000	0.00002
10	traces	20,000	0.00001

The results are almost identical; the only action of the pyrogallol being the absorption of oxygen and its being found in excess.

(b) Sulphuric acid: 106 g. per liter.

Electrolysis.			
g.	Exterior resistance.	Intensity i .	Hydrogen per minute.
	Ohms.	Amp.	Mg.
Pyrogallol 10	distinct	2,000	0.00006
10	slow	5,000	0.00006
10	traces	8,000	0.00001

There appears to be less sensibility with this proportion of acid.

(c) Sulphuric acid: 1 g. per liter.

Electrolysis.			
g.	Exterior resistance.	Intensity i .	Hydrogen per minute.
	Ohms.	Amp.	Mg.
Pyrogallol 10	distinct	1,000	0.00002
10	slow	2,000	0.00006
10	traces	6,000	0.00006

(d) Acid: 1 g. per liter.

Electrolysis.			
g.	Exterior resistance.	Intensity i .	Hydrogen per minute.
	Ohms.	Amp.	Mg.
Pyrogallol 100	distinct	500	0.00006
100	slow	2,000	0.00010
100	traces	5,000	—

The electrolysis occurs less and less distinctly r

der a given resistance, when the excess of pyrogallol is very much increased: the presence of this compound doubtless modifying the cohesion of the liquid, and consequently the facility of disengaging bubbles.

3. Sulphuric acid and pyrogallol. variable determining electromotive force. I have varied this force from the value equivalent to 6 Daniells to 1 Daniell; or E , from 5.8 volts to 0.03 volt.

During experiments made with different elements of a battery, E has been reduced to 0.03 volt; the limits have been found the same. I give now only the results obtained with Daniell elements under two different pressures.

(a) Under the normal pressure 0.760 m.:

	Electrolysis.	Exterior resistance, ohms.	Limit of intensity, amp.	Hydrogen per minute, mg.
1 Daniell $E_1 = 0.3$ volt	distinct	3,000	0.00016	0.00010
	slow	4,000	0.00008	0.00005
6 Daniells $E_1 = 5.8$ volts	distinct	40,000	0.00015	0.00009
	slow	50,000	0.00012	0.00007

(b) Under the pressure 0.005 m.:

	Electrolysis.	Exterior resistance, ohms.	Limit of intensity, amp.	Hydrogen per minute, mg.
1 Daniell $E_1 = 0.3$ volt	distinct	30,000	0.00010	0.00006
	slow	50,000	0.00006	0.00004
6 Daniells $E_1 = 5.8$ volts	distinct	200,000	0.00012	0.00007
	slow	300,000	0.00007	0.00004

The intensity limit is essentially the same with one and with six Daniells, under the same pressure which is in accord with the result obtained without pyrogallol in the voltmeter.

Such are the facts observed. It would certainly be unsafe to claim that below these limits there is no further electrolysis; but it is the term below which in the conditions under which I operated, the gases produced remained dissolved. If the reaction is prolonged, they are disguised without apparent manifestation in the surrounding spaces; or they combine perhaps again little by little in consequence of polarization.

The remark may be made here, in order to state accurately the present results, that it is true that an electric current, be it ever so feeble, always passes through a liquid conductor; it appears, however, as I have proved through my researches on the combination of hydrogen and oxygen with platinum, a metal suitable for electrodes in batteries, that the necessary chemical energy is, in reality, always present to begin the action, but not to sustain it, a capital distinction. It is a fact that the voltaic energy could not produce a continuous exterior electrolysis, unless it were sustained by an interior reaction equally continuous and capable of maintaining an electromotive force whose value exceeds a certain limit. Otherwise the renewal of energy attributable to the phenomena of diffusion and analogous, is too small to produce a continuous and manifest electrolytic result; while the action of contact is, on the contrary, sufficient to establish a difference of potential between the two batteries.

If the weights of hydrogen manifested in these experiments are compared with the weights of silver which may be precipitated by the same degrees of intensity, it will be found that a millionth part of a milligramme of hydrogen per minute is equivalent to a ten-thousandth part of a milligramme of silver, a quantity that cannot be weighed and is almost imperceptible. At the end of an hour, there would be a hundred and sixtieth part of a milligramme of silver. For a ten thousandth part of a milligramme of hydrogen, there would be only a hundredth of a milligramme of silver per minute; hardly more than half a milligramme per hour. The disengagement of hydrogen is therefore much more perceptible.

The order of the greater or less extent of the reactions of batteries determined by these experiments, is compatible with normal physiological phenomena which too energetic reactions of electrolysis would disturb profoundly.

It corresponds also with the slight weight of matter converted into acids in twenty-four hours by the production of secretions as well as with the almost infinitesimal quantities produced every second, while each wave of blood traverses the secreting organ. These are conditions which must not be lost sight of.

In order to elucidate this comparison, let us consider the formation of chlorhydric acid, contained in the gastric juice. Suppose 0.100 g. to be the weight of this acid, HCl, contained in the juice secreted in twenty-four hours by the coats of the stomach; this weight is derived from the liquid of about 86,000 sanguinary waves projected by the heart, on the hypothesis of a uniform secretion. Every one of these waves furnishes about a millionth of a milligramme of chlorhydric acid, a weight which would correspond with the setting free by electrolysis of about three hundred-millionths of a milligramme of hydrogen according to Faraday's law. Now, this quantity is produced by the action of several millions of these little organs of varied functions, which we confound under the name of cells; the visibility of the complexity of structure correlative to these functions escaping our senses. The average weight of acid originated by each one of these at the expense of a single wave of the blood would therefore be equivalent to a few quadrillionths of a milligramme of hydrogen. However, the integration of this production of acid furnishes the total weight which determines the diurnal effects of the digestion of the stomach and especially of that of nitrogenous food. By this it will be understood why the formation of compounds contained in animal secretions—acids, alkalies, products of oxidation or of reduction, toxins, poisons, vaccines, etc.—should be susceptible of accomplishment by certain combinations of batteries founded on saline reactions; the very feebleness of these reactions being compatible in regard to their nature and intensity with the normal functions of our organs.

On November 24, the Rapid Transit Commission granted the franchise applied for by the Hudson and Manhattan Railroad Company to build a tunnel under the North River from Jersey City to Cortlandt Street. The new railroad will continue under Cortlandt Street to Church Street and then by means of a loop to Fulton Street back to the tunnel. The terms of the franchise have already been reported. It goes to the aldermen now.

AN ALPINE AUTOMOBILE RELIABILITY TRIAL.

I WAS at Southport watching the touring cars pursuing an unemotional course over the level promenade when a telegram from Capt. Deasy was brought to me, asking me to join him in an attempt to ascend a mountain in a Martini motor car, and to betake myself for that purpose to Caux, above Montreux, in Switzerland. As I knew that district I at once concluded that he in-



THE ROCHERS DE NAYE, FROM CAUX.

tended to climb the Rochers de Naye, but it beat my comprehension how it was to be managed, as I could recall no route to the summit which was in the least degree practicable for a motor car. However, knowing both Capt. Deasy and the Martini car, I concluded that at any rate I should see some sport, so I promptly wired acceptance. I was still wondering what could be Capt. Deasy's route, when I opened my newspaper on Tuesday, October 6, and found that he had made a journey up and down the cog-wheel railway. I was astounded, for I had a lively recollection of descending the line in a railway carriage that was apparently desirous of standing on its head, and that the track was possible for a car had never suggested itself to me.

Dismissing from my mind the consideration of the perturbing question whether my accident insurance company would, in the apparently not improbable event of my untimely demise, regard the episode as motor-car traveling or premeditated suicide, I hur-

wheels of the car must be within a foot of the edge of the precipice, and that the bottoms had been put into the valleys quite unnecessarily far down, I began to think that the undertaking was a stiff proposition.

However, there was Capt. Deasy, calm and confident, and he took me off to examine the car. Naturally, I expected to find that in view of the feat it would embody some material alterations from the ordinary pattern, especially in the matter of the height of gearing. I was surprised to learn that it was a 14-horsepower Martini touring car, which had been employed in traveling about Switzerland and elsewhere for the past three months by M. Ernest Cuénod, the well-known motorist of Paris and member of the French Extra-Parliamentary Commission on automobiles. For use on mountain roads a special cylindrical reservoir for petroleum was fitted on top of the dashboard, so as to insure that the flow of spirit by gravity should not be interrupted when the carburetor was higher than the fuel tank. The gearing was only reduced by two teeth for Capt. Deasy's exploit. Instead of an eleven-tooth sprocket a nine-tooth gear wheel was fitted, and as with the former gear the Martini car did 42.3 miles an hour at Bexhill in the reliability trials, motorists will realize that the reduction in gearing was extraordinarily small in view of the task which was put before the vehicle; and it was not even so much as appears, for 100-millimeter Continental tires were fitted instead of the 90-millimeter ordinarily used, thus increasing the diameter of the wheels. Another alteration from the usual condition of the car was the fitting of a curved plate under the fore axle so that if, by the failure of a tire, the front of the car dropped, it would not catch in the rack of the railway. An extra long sprag was fitted; but I did not put much faith in that, for the chances were that if we ran backward it would sink into the loose ballast and we should "jump" it. And "jumping the sprag" on a gradient of 1 in 4½ at the edge of a precipice would have been more exciting than conducive to longevity. The car was fitted with a phaeton body and weighed 19 hundredweight. The engine has, of course, four cylinders, with mechanically operated valves. Throttle control is effected by a lever on the steering wheel. The ignition is magneto.

The car having proved such as to give confidence, we proceeded to take certain measurements, which were less encouraging. The distance between the running rails of the line is 2 feet 10 inches; between the wheels of the car is 4 feet 1 inch; from outside to outside of the wheels is 4 feet 5 inches; and the breadth of the crown of the ballast track is usually 6 feet 9 inches, so that when the car is centrally placed there is a space of 1 foot 2 inches from the wheel to the edge. This is sometimes even less, and any motorist who feels quite secure in steering his car with a margin of a foot should try the experiment on the edge of a precipice and note the microscopic dimensions of twelve inches. In the photograph the track looks wide, but that is because the curving side-merges with the crown. I need hardly say that Capt. Deasy could not afford to take the risk of running a wheel off the crown, the more so as the ballast was quite loose. This brings me to another point which adds very greatly to the remarkable nature of the feat, that the surface was throughout composed of



CAPT. DEASY AND COMPANION ASCENDING FROM CAUX.

riedly departed for Caux, and, on arrival, at once went by train to the summit of the Rochers de Naye Railway, 6,485 feet above the sea, and 3,457 feet higher than Caux. On the ascent I took comfort, for, as in all mountaineering, when one looks upward the effect on the nerves is minimized. Even so, the route was not the one that I should have chosen for a peaceful drive. But on the descent, when I looked out into space and noted that in many places the

granite stones like a newly-metalled road. Had the surface been good the achievement would have been surprising, but when it was formed of loose stones and steel sleepers it becomes phenomenal.

It is curious to reflect that in all our arrangements only one item gave no cause for anxiety, and that was the car. The weather, the photographers, the railway officials, the state of the roads, all presented difficulties; the car offered none. Capt. Deasy's project of

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repeating his complete journey to the summit of the railway and back was frustrated by the weather. On Thursday, October 8, the sun was so hot that one could not sit in its glare on the terrace of the Caux Palace Hotel. Friday was cold and showery; Saturday opened with violent storms, and when I went with a party of cinematographers to the Rochers de Naye to survey the route we found three feet of snow drifted in places, and more descending in blinding clouds. The railway officials declared that there was practically no hope at this time of the year of the route becoming sufficiently clear for Capt. Deasy to carry out his scheme, and after a council of war it was decided to take the first opportunity to make whatever ascent the track allowed. Fortunately the next day was fine and bright, and inspection showed that the route was clear up to Crêt d'Ybau, a distance of 1 1/4 miles. One mile of this has a gradient of 22.5 per cent, and it therefore provided an ample test. A good crowd of keenly interested spectators witnessed the start in the afternoon from Caux Station.

How shall I describe the journey? Almost it may be said that it was so successful as to have no history. Capt. Deasy and I went up, and at the outset is one of the trying parts of the trip, for the car has to cross a switch; and when, as was the case here, there are two sets of cross rails, each of them with its cogged rail, this is a body-racking process. The car had to be put at them pretty strongly in order to get over, and the passenger feels as if he were a pea bouncing in a bladder, and prays that the seat may be under him when he comes down after being violently jolted upward. As a test for the stanchness of the springs, wheels, and axles, it was conclusive; while tires that did not pull out under such a strain must be pretty strongly fixed in the rims. However, in a few yards we found ourselves on an even keel again and the car began to ascend. The opening gradient is 8 per cent, rapidly increasing, until after about 400 yards we rounded a bend and found ourselves confronted with 22.5 per cent. A little more gas was given and the engine deepened its note, humming with that healthy clearness of tone which is so musical to the ear of the motorist. Without a falter we went steadily up, too fast indeed for the train which was following with the cinematographers. Not many motorists would care to slow down their engine on a steep hill, much less on a newly-metalled slope of 1 in 4 1/2, but in response to the signals of the camera men, Capt. Deasy throttled down a little to allow the train to come within range, its sides bristling with the heads of spectators craned out of the windows to watch our progress. About half a mile up the steepest part Capt. Deasy stopped the car to wait while the cinematographers took up a position on a bank commanding a good view of a curve in the route. When they were ready the most surprising part of the demonstration occurred, for on the grade of 1 in 4 1/2, covered with loose stones, the car started again without the slightest trouble and went off with ease up the grade and round the curve depicted in the illustration.

Now we turned the car round for the descent, and we took on board three more passengers, M. Max de Martini, M. Cuénod, and M. Eulenstein, manager of the Caux Palace Hotel. The total weight of car and travelers was 26 1/2 hundredweight, but with this load the brakes held perfectly.

of a precipice, was only stimulating. It must be confessed, however, that on the down grade the perils of the adventure were much more apparent. One looked off into space, and the precipices seemed so much



A STIFF GRADIENT.

nearer and the valleys so much deeper that if one had not had complete confidence in the car and its driver the ride would hardly have been enjoyable.

I questioned Capt. Deasy about his earlier run. The

that the wheels could get no grip. The tunnel was very dark, and it was an eerie sensation to hear the reverberations of the engine and the noise of the wheels scattering the stones, and to be unable to tell whether the car was climbing up into the sunshine or sliding back into the *ewigkeit*.

Capt. Deasy's exploit was a remarkable demonstration of the power and control of the car, and it is not surprising that Messrs. Deasy & Co. have bespoken the whole of next year's output of Martini cars. But Sunday's trip was very near being frustrated by a startling occurrence. In the morning Capt. Deasy, with M. Cuénod, M. Max de Martini, and M. Eulenstein as passengers, drove the car down a gradient of 22.6 per cent on the line where it passes under the grounds of the Caux Palace Hotel. He had to cross a bridge just before this point. This bridge amply supports the rails, but outside them are planks for the employees of the line to walk over. As the car was crossing, a plank near to the left-hand rail suddenly broke. First the front and then the hind wheel dropped, and the car gave a terrifying lurch. Fortunately Capt. Deasy kept the steering wheel steady, and what with the momentum and the gradient the car jumped up again over the transverse steel joists and passed on into safety. The plank was discovered to be so rotten that it could be broken with the hands; but how narrow the escape had been was not realized until later, when it was found that the wheels of the car had just landed on a flange of the steel beam supporting the rail longitudinally. Had they been a couple of inches further out they must have dropped so far that almost inevitably a bad smash, and probably an overturn of some 15 feet into the roadway below, would have resulted. I asked Capt. Deasy to repeat the performance so that I could photograph it, but he and his passengers begged to be excused. They found one experience completely satisfying.—The Car.

THE DEVELOPMENT OF THE SUBMARINE IN THE DIRECTION OF INCREASED SCOPE.*

A STUDY OF THE LAKE SUBMARINE TORPEDO BOAT "PROTECTOR."

By Lieut. JOHN HALLIGAN, Jr.

THE MILITARY STRENGTH OF THE SUBMARINE.

The submarine, when within torpedo range, is the superior of the battleship, since the battleship is vulnerable to the torpedo—the weapon of the submarine. In the ability of the submarine to submerge itself to considerable depth, and thus secure the protection of an incompressible liquid medium, the craft possesses the power to assume an indefinite thickness of armor. This, combined with its invisibility, makes the submarine doubly secure from the gun—the weapon of the battleship.

The present state of development of the submarine, with its automobile torpedo, is such that when the boat is submerged and within torpedo range, it must be admitted that the disablement or destruction of the battleship is probable—the degree of probability and the amount of damage depending principally on the number of torpedoes that can be discharged by the submarine, and on her facilities for locating and estimating the range of the target. Thus the submarine, within the limitations given above, is eminently successful.

THE MEASURE OF ITS EFFICIENCY.

The value of the submarine as a formidable weapon of war will depend primarily upon three factors: First—The ability of the commander of the boat to place his vessel within torpedo range of the enemy. Second—The ability successfully to discharge the torpedo. Third—The character of the personnel.

In the present phase of submarine-boat development, considering the varying conditions of distance, state of sea and weather, as well as the probable speed and course of a watchful enemy, the power of placing the submarine well within torpedo range constitutes by far the most important factor of the problem. Inasmuch as the different types may be supposed to be armed with the same efficient and trustworthy type of torpedo, and as the daring and skill of the personnel may be equal for all types, it is seen that the true measure of the efficiency of any submarine boat is the ability successfully to place itself within torpedo range of the enemy. When the earnest call for the submarine comes, the final measure of comparative worth of existing types will rest upon their ability to attain a position of advantage against the enemy.

And the logical development of any type of submarine will be such as will tend to render the attainment of this position the more certain.

THE ATTAINMENT OF A POSITION WITHIN TORPEDO RANGE.

This involves—

(a) Ability of the boat to submerge quickly and at will.

(b) Absolute control of depth of submergence.

These are the properties which may be regarded as the fundamental desiderata of a submarine, and, therefore, in determining the comparative worth for naval purposes of distinct types of such construction, the greatest values should be ascribed to the factors or qualities which in all vessels of war tend—

I. To increase the craft's scope or radius of action from a fixed base.

II. The ability to readily and rapidly change base.

III. The ability to abandon the base or to intercept the vessels of an enemy.

These qualities of efficiency and endurance in war vessels have likewise been thus expressed:

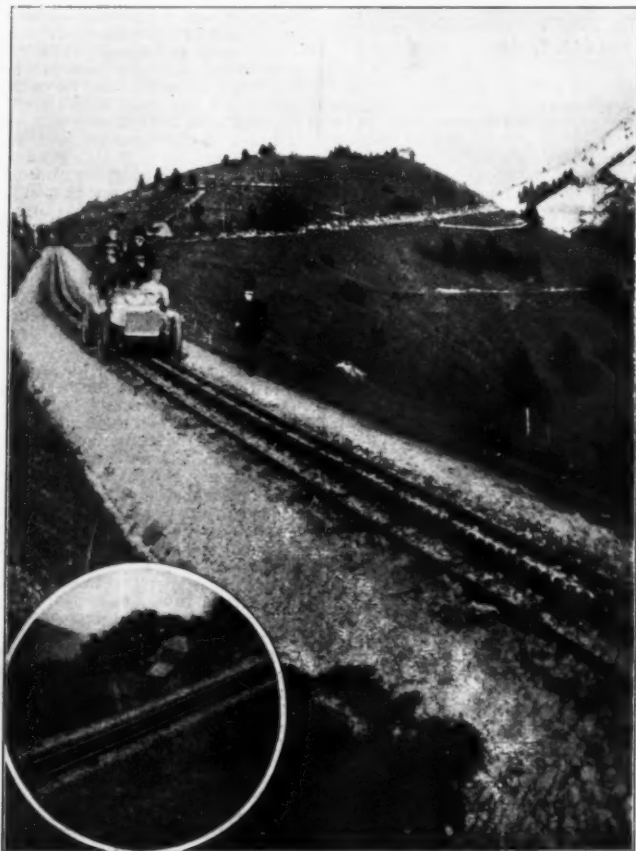
(a) Seaworthiness. In case of submarines, safety and stability in surface, awash, and submerged condition.

(b) Speed. For submarines, surface and submerged.

(c) Cruising radius and habitability. The one useless without the other.

(d) The navigational facilities. Particularly in

* Reprinted from the Journal of the American Society of Naval Engineers.



A SAMPLE OF THE INCLINE. THE MARTINI DESCENDING WITH FIVE PASSENGERS.

It will be asked, What were the sensations of so extraordinary a run? On the ascent the car mounted so steadily and pleasantly, despite the bumping on the sleepers, that the sense of danger, even on the verge

only part of it which had given him trouble was the tunnel, 300 yards long, through the Col de Jaman. In the tunnel oil from railway engines and water from the roof had made the track so soft and slippery

submarines should this factor be regarded as of importance, since heretofore, in many types of craft, it has been maintained that the boat is blind.

SUBMERGENCE BY DIVING.

The first qualities demanded of the submarine are, naturally, those of ready submergence and ability to maneuver at will while submerged. Indeed, in most types of the past, this, except for ability to place or discharge a torpedo, was the only accomplishment hoped for, speed, seaworthiness, and cruising ability being considered as foreign to the type.

Of the four methods of submergence developed in the history of submarines, namely, submergence by destruction of buoyancy, by vertical propellers, change of volume of displacement, diving, with slight reserve of buoyancy, the last survived.

It has been claimed by advocates of this method (and justly, so long as there was no proof to the contrary) that this furnishes greatest facility in submerging, and the best control of depth of submergence while under way.

THE SCOPE OF THE SUBMARINE OF THE PAST.

Heretofore it has been generally accepted (in this country at least) that the submarine, like the devil fish, must, to a great extent, lie in wait for its prey. In accordance with such estimate, practically all official tests of submarines have been conducted in landlocked harbors, whose depth of water is less than that off shore, where it is presumed that the submarine would be expected to operate in time of war. The submarine has thus been granted the security of a harbor for base of operation, and its field of usefulness has been narrowed to the defense of that particular harbor. Changes of base as well as cruises to distant points have generally been made heretofore from the end of a towline.

AN ATTEMPTED ENLARGEMENT OF SCOPE.

The development of the "Protector" is of particular interest to the service in that she is an attempt at enlarging the scope of the submarine, principally along the headings outlined above.

The first and most difficult problem in the designing of such a boat was the combination of facility of submergence with seaworthiness under severe conditions. A sacrifice of longitudinal stability is essential in the diving type of submarines to render diving effective at the submerged speeds attainable. This instability must impair the sea-going qualities of the submarine, and it was to overcome this inherent disadvantage and weakness that the designer of the "Protector" effected a modification of means of submergence whereby the stability of the submarine would be increased and her radius of action extended.

The combination of facility of submergence with comparatively great longitudinal stability secured in the "Protector," is the most remarkable feature of this interesting boat.

THE "PROTECTOR'S" PEDIGREE.

"Argonaut, Jr."

The "Argonaut, Jr.," was built in 1894-5, of yellow pine timber painted with coal tar, and was 14 feet long, 4½ feet wide, and 5 feet high. She was propelled by hand power on a crank operating the driving wheels, her function being simply that of traveling along the bottom. Compressed air was carried in a soda water tank, and a plumber's hand pump served as an air compressor.

In spite of this crudeness of construction, the "Argonaut, Jr.," demonstrated the practicability of the diving compartment, her diving door having been opened at a depth of 16 feet. At this depth a diver was sent out, and the efficiency of the system was thus effectively demonstrated.

"Argonaut 1st."

This vessel, of steel, 36 feet long, and with 9 feet beam, was built in Baltimore, in 1897. She carried a 30-horsepower White & Middleton gas engine, a dynamo, air compressor, searchlight and water-ballast pumps. As in the "Argonaut, Jr.," she was provided with a diving compartment, with geared wheels for movement along the bottom of the coast, and with a screw propeller for surface propulsion.

Although her size provided very little accommodation for the crew, as well as very limited carrying capacity, five men cruised over two thousand miles in her, on the surface and submerged, during 1898, in Chesapeake Bay and on the Atlantic Coast.

The "Argonaut 1st" is responsible for the development of the present large superstructure of the "Protector," the extended cruising of the "Argonaut" having demonstrated the advisability of this construction for securing greater buoyancy in the cruising condition, with corresponding increase of seaworthiness, increased deck room and larger fuel capacity.

"Argonaut 2d."

During 1899 and 1900, the "Argonaut 1st" was reconstructed and became "Argonaut 2d." As reconstructed, for wrecking purposes, she has a spindle hull 56 feet long, with 9 feet beam. She carries a buoyant superstructure wherein are installed air and gasoline tanks. She is 66 feet long, and, with a beam of 10 feet, her appearance in the cruising condition resembles that of a small schooner. She carries a 60-horsepower White & Middleton gas engine, dynamo, two air compressors, pumps, anchor hoists, telephones and a 4-horsepower auxiliary engine. In her bow is a searchlight for illuminating the bottom when doing sub-surface work. She has accommodations for a crew of eight men, and estimated cruising radius of 3,000 miles.

WHAT THE "PROTECTOR" OWES TO HER PREDECESSORS.

Her predecessors served to develop the following features, which have been incorporated in the "Protector":

1. Diving door and compartment.
2. Superstructure.
3. Utilization of the bottom as a guiding medium by means of wheels in the bottom of the boat.
4. Control of depth of submergence, when not under way, by means of anchor weights.
5. Conning tower of considerable size.
6. An installation of gas engines which can be used while the boat is partly submerged.

7. Numerous less important details.

The important features of the "Protector," which were not successfully developed and tested in her predecessors, are:

- Control of depth of submergence by hydroplanes.
- Storage-battery installation.
- Omniscope.
- Handling and firing of torpedoes.

THE "PROTECTOR."

General Dimensions.

Length over all, feet and inches.....	67-6
Beam, extreme, over guards, feet and inches..	14-2
Depth from top of omniscope with wheels down, feet and inches.....	24-¾
Draught, light cruising condition, feet and inches.....	11-9¾
Displacement, light, tons.....	136.3
Displacement, awash, tons.....	157.1
Displacement, submerged, tons.....	174.35
Area midship section, cruising trim, square feet.....	102.32
Area midship section, submerged, square feet..	147.2
Height of C. G. above base of keel, inches.....	83
Height of C. V. above base of keel, inches.....	98
C. G. below C. V. (cruising trim), inches.....	15
C. G. below C. V., deck awash, inches.....	9
C. G. below C. V., submerged, inches.....	7.3
Height of C. G. above base of keel, superstructure full, ballast tanks empty, inches.....	93
Height of C. G. above base of keel, superstructure and conning tower full, ballast tanks empty, inches.....	96
C. V. aft of forward vertical, inches.....	371.4
C. G. aft of forward vertical (cruising trim), inches.....	374
C. G. aft of C. V. (cruising trim), inches.....	3.16
Tons per inch immersion at cruising trim.....	1.3

The following is as detailed a description of the "Protector" as can at this time be made public, and is necessarily very incomplete:

CONSTRUCTION.

The "Protector" consists of a heavy spindle hull of



MR. SIMON LAKE'S FIRST SUBMARINE, THE "ARGONAUT, JR."

mild steel, 65 feet long, and with a maximum diameter of 11 feet, 2 inches, with conning tower, designed to withstand an external pressure corresponding to a depth of 150 feet and carrying a light superstructure.

Hull.—There are thirty-six main frames spaced 20 inches apart. That portion of the spindle hull between frames No. 10 and No. 21 is cylindrical.

Hatch openings in the spindle hull at frames No. 8, No. 19 and No. 24, are respectively, 27¾ inches by 24 inches (elliptical), 22 inches by 24 inches (elliptical), and 32 inches by 32 inches (circular). Hatches are locked by sliding dogs operated by hand wheels and screws, providing great leverage.

Bow and Stern Castings.—Bow and stern castings are of malleable iron, conical in shape. The forward cast-



THE "ARGONAUT SECOND," WHICH WAS CONSTRUCTED BY LENGTHENING AND IMPROVING THE "ARGONAUT THE FIRST."

ing provides housing for the forward anchor, and the after one stuffing boxes for the vertical rudder post and operating shaft of horizontal rudder and a pocket for the pivot of the horizontal-rudder bell crank.

Keel.—The keel extends from frame No. 3 to frame No. 31, and has a depth of 17 inches amidship, tapering to nothing at the ends. It is worked in two side pieces or cheeks of steel, filled in, except at wheel pits and drop keel housing, with yellow pine, cut to fit, and bolted through.

Bulkheads.—At frame No. 6 is an air and watertight bulkhead designed to stand a test pressure of 75 pounds to the square inch.

Tank bulkheads are worked to the height of the floor plates. At frame No. 18, between the crew space and galley, is a frame carrying swinging doors, and at frame No. 20, between galley and engine room, the switch board serves as a partition bulkhead.

Superstructure.—A superstructure is provided for the following purposes:

I. To give buoyancy and seaworthiness in the cruising trim.

II. To provide stowage for fuel and air tanks outside of the spindle hull, for reasons of safety and economy of space.

III. To give deck room, thus contributing to habitability.

It is carried up from the greatest diameter of the spindle hull in a vertical direction, and is of comparatively light construction. Midway in the length is a watertight transverse bulkhead, which divides the superstructure into two ballast tanks, fitted with suitable admission and discharge valves.

Access to within the superstructure is afforded through fourteen elliptical manholes, 16 inches by 12 inches.

Air and Oil Tanks.—In the superstructure are carried:

Eight gasoline tanks of galvanized steel, with a combined capacity of 1,050 gallons, built to stand a hydraulic pressure of 100 pounds to the square inch.

Six high-pressure air tanks of 8-inch Mannesmann tubes, with a combined capacity of 21 cubic feet, built to stand a test pressure of 4,000 pounds to the square inch.

Two lubricating oil tanks, similar in construction to the gasoline tanks, with a combined capacity of 120 gallons.

Four low-pressure air tanks, similar in construction to the gasoline tanks, with a combined capacity of 12½ cubic feet.

All the gasoline tanks are connected to those on the same side of the ship, and all tanks on each side are connected with a copper service tank, fitted with gage glass and float which automatically shuts off the supply. These service tanks are situated in the engine-room compartment abaft the engines.

All gasoline connections are of seamless brass tubing with brazed joints.

Connection between the high and low-pressure air systems is made through a special Foster reducing valve, in the galley compartment, which reduces from 2,000 to 60 pounds.

Ventilators.—Ventilating trunks, consisting of cylindrical bronze castings, 6 inches in diameter, worked watertight through spindle hull and superstructure deck, carry miter valves operated by hand wheels from within the spindle hull.

They are situated between frames No. 11 and No. 12, and between frames No. 27 and No. 28. Galvanized-iron cowls, 11 inches in diameter at mouth, screw on these in the usual manner.

Watertight bronze caps cover the valves when cowls are unshipped.

Deadlights.—The spindle hull is lighted through deadlights, in trunks, worked through the superstructure, and provided with clapper valves serving as battle ports.

At a depth of 40 feet it has been found that the hull is reasonably well lighted, it being possible at this depth to read a newspaper under the deadlights without the aid of artificial light.

Torpedoes and Tubes.—The hull is pierced for three tubes with axes 3 feet 5 inches above center of spindle hull, two of which are forward, accessible from the crew space, with axes 4 feet apart, and one in the stern, opening into the engine room. In the light condition the tops of the tubes are awash.

The doors carry ¾-inch square rubber gaskets. The outer doors of the forward tubes house upward and inboard into a spectacle-shaped housing built into the superstructure.

The outer door of the after tube hinges at the bottom and drops to a horizontal position.

A firing pressure of 60 pounds from the low-pressure system is used.

The "Protector" is intended to carry 3.55 M. Mark III Whitehead torpedoes, three in the tubes and two spare ones (if considered desirable) under the berths in the crew space.

Torpedoes are taken aboard either by being floated into the tubes while the boat is in the light condition (which is the preferable method), or by removing the tails and striking them down the engine-room hatch. Within the boat they are handled by trolley straps hung from detachable rails in the rear of tubes.

The boat's stability while submerged (both longitudinal and transverse), is such that the torpedoes may be loaded without materially affecting the trim of the boat or the control of depth of submergence.

Much trouble has been experienced in preventing corrosion of the shell of the torpedo furnished the "Protector," due to the unavoidable dampness of the submerged tube. It seems very probable that in the event of a material increase in the number of submarines a torpedo with a bronze shell will be requisite.

Diving Compartment.—This forward compartment is, perhaps, the most spectacular feature of the boat. It is separated from the crew space by the air and watertight bulkhead at frame No. 6, and by an air lock, 42 inches long, built into this bulkhead, and fitted with air and watertight doors—the whole being designed to stand a pressure of 75 pounds to the square inch.

The diving compartment is fitted with a connection to the low-pressure air system, a telephone, and a gage with two hands, one of which registers the pressure due to depth of water, and the other the air pressure within the compartment.

In the bottom of the compartment, forming a portion of the hull, is a cast iron door, hinged at its after end and stiffened with transverse ribs, which, when the door is open, serve as steps.

It is raised by small hand winches, with wire-rope falls, and secured with dogs. Around the door is a coaming extended 30 inches above the hinge door.

To open the diving door when resting or running along the bottom, the air-lock doors being closed, a

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valve on the air connection is opened, and the pressure in the compartment allowed to increase gradually until the two hands on the gage balance. A try cock in the door is then opened, and the balance of the pressures verified. The door is then undogged and allowed to swing open, giving, in clear water, a good view of the bottom.

A diving suit, fitted with telephone connection, is provided; the air hose being connected with a low-pressure air tank in the compartment, the pressure being controlled by the diver, through a valve in his helmet. Thus persons in the diving compartment are in telephonic communication with the diver and with the rest of the boat.

The diving compartment provides for:

- I. Cable cutting.
- II. Destruction of mines.
- III. A means of escape for the crew, in case of total disablement of the boat.
- IV. A means of communication with shore by cable when on picket duty.

In demonstration of these features the diving door has been opened five times in the writer's presence, in depths up to 32 feet. A member of the crew in diving suit and one in a bathing suit have been sent out, the latter to demonstrate the method of escape.

Wheels.—Two hollow cast-iron wheels, 34 inches in diameter, and with 10-inch rims, are hung by forged-steel jaws, pivoted through the cheeks of the keel at frame spaces No. 6 and No. 21½, and connected with hydraulic operating cylinders which are cushioned by pneumatic cylinders. The wheels house in pockets in the hull.

The pressure in the hydraulic cylinders, by which the wheels are raised and lowered, is obtained from a hand pump forward in the crew space. This installation is designed—

- I. To permit the utilization of the bottom as a guiding medium. The conformation of the Atlantic Coast is, in many localities, such as to permit a submarine to run along the bottom well beyond blockading range without reaching her limit of depth (which, in the case of the "Protector," is 150 feet). In a boat running thus, control of depth of submergence is unnecessary, and, being free from the influence of currents, a much straighter course can be steered than when running between the surface and bottom.
- II. As complementary to the diving compartment in cable work, etc.

The cushioning of the hydraulic cylinders is intended—

- I. To enable the boat to take the ground without injuring the hull. When submerged the "Protector" is always kept on nearly an even keel. In moderate depths (of less than 150 feet), with fairly smooth bottom, the commanding officer is thus relieved of a great deal of anxiety, inasmuch as a sudden descent to the bottom, due to loss of control, can have no harmful results. In submerged runs the "Protector" has frequently been allowed to take the bottom. This has always been accomplished without jar or shock.
- II. To allow the boat to rest on the bottom in a ground swell, as in weathering a heavy storm.

Experience in the "Argonaut First," while lying on the bottom off Cape Henry, demonstrated that, at a depth of 30 feet, the ground swell was such as to lift and drop the boat 10 inches, with results disastrous to the machinery. The effect of this drop, if not cushioned, is almost irresistible, inasmuch as the hull receives a thrust due to the weight of the water above it.

To utilize the wheels, the boat is given a slight negative buoyancy, causing her to rest on the bottom with a weight of only a few hundred pounds, thus allowing her to run over soft or irregular bottom. It is said that the "Argonaut" has climbed the 10-foot side of a channel dredged in clay. The wheels are in the nature of rollers, propulsion being as in the other stages of submergence. While running in this condition, if an observation is desired, the boat is brought to the surface by the hydroplanes.

Anchor.—The forward anchor is mushroom in shape, weighs 500 pounds, and is of gray iron, cast with an eye in its end, to which is secured a ½-inch steel-wire cable 250 feet long. The anchor hoists into a sheet-steel housing riveted to flanges on the stem casting. The cable is led up through a wrought-iron hawse pipe over a pulley in the superstructure deck, and through guides on the deck to a winch.

The after anchor is a dome-shaped gray-iron casting, weighing 500 pounds, and fitted with a cable similar to that of the forward anchor. Its housing is a cast-iron dome fitted and riveted in the spindle hull between frames No. 32 and No. 33.

The anchors are hoisted by electric winches, operated from within the conning tower, the motors for which are in the after crew space.

The anchors, in addition to their use as such, serve as weights by which the control of depth of submergence is obtained while not under way. For this the boat is trimmed with a reserve buoyancy somewhat less than the combined weight of the anchors, and, with the anchors on the bottom, the boat is raised or lowered by paying out or heaving in on the cables. Thus, while at anchor in a submerged condition, as she might be under certain conditions of picket duty, the boat can rise for an observation and submerge at will.

Conning Tower.—A conning tower of considerable proportions is provided, for the following reasons:

- I. To provide a buoyant moment well above the center of gravity, thus contributing to stability.
- II. To localize the control when submerged.
- III. To facilitate the surface navigation of the boat in comparatively rough seas.
- IV. To provide a compass location well removed from the magnetic influence of the spindle hull.

The conning tower is 10 feet 1 inch long, 4 feet 7 inches wide, elliptical in plan, extending 6 feet 5 inches above the spindle hull, and is situated between frames No. 14½ and No. 20½. For a height of 33 inches the structure is of steel plate, the remainder being of Tobin bronze. All joints are machined.

The conning tower carries a sighting hood, omniscopes, hatch, and suitable lenses affording an all around view of the horizon.

Within is most of the controlling mechanism of the boat, namely:

Steering wheel for vertical rudder.

Operating wheel for hydroplanes.

Wheel controlling horizontal rudder.

Engine and motor telegraphs.

Telegraph controlling engines, motors, and pumps.

Controlling gear of electric anchor hoists.

Valves for filling superstructure.

Air vents and air connections controlling filling and blowing out of superstructure and ballast tanks.

Gages and dials as follows:

One 15-inch depth gage registering to 75 feet.

One 6-inch depth gage registering to 150 feet.

Dial showing inclination of hydroplanes.

Dial showing inclination of horizontal rudder.

Clinometer showing longitudinal trim.

Buoyancy indicator.

Water column showing level of water in superstructure.

When in cruising condition, a detachable steering wheel and engine telegraphs are shipped on top of conning tower.

Compass.—In the dome of the conning tower, forward of the sighting hood, is worked a bronze compass case, carrying a Ritchie compass with a 7-inch double card, visible from above and below, and situated 3 feet 2 inches above the steel portion of the conning tower, and 5 feet 11 inches above the spindle hull. This location, combined with the steadiness of the magnetic plane when submerged (the boat always remaining on nearly an even keel), contributes to sensitiveness and accuracy of the compass. The compass, as compensated, with but one quadrantal and no semi-circular correctors, has a maximum deviation of ¼ point.

Hydroplanes.—There are two hydroplanes on each side, flush with the superstructure deck, pivoted at frames No. 13½ and No. 22, and protected by a heavy steel guard, extending between frames No. 8 and No. 28.

They are operated in unison, through a system of cranks, shafts and bell cranks, from within the conning tower, and have a throw of about 15 degrees above and below the horizontal.

While running submerged, the depth of submergence is controlled by balancing the reserve buoyancy with the downward thrust, due to the depression of the hydroplanes.

Horizontal Rudder.—The horizontal rudder, of 10.8 square feet area, is carried on a steel shaft with habbitted bearings in the stern casting and struts. It is controlled through bell cranks and operating shaft from the conning tower, and has a throw of 10 degrees in each direction.

Drop Keel.—The drop keel is in two castings, of gray iron, with a combined weight of 10,000 pounds. Each casting is generally square in section, 17 inches by 17 inches by 7 feet 2 inches long. One end of each is curved to a 6-foot 6-inch radius, to give clearance in dropping, and the other ends are fitted to rest on sloping shoulders, worked in the regular keel for that purpose. The curved middle ends are hung by a T-headed bolt, worked in suitable pockets, and controlled by a shaft led up through a pipe and stuffing box to the level of the flooring in the crew space. While submerged, a wrench is kept shipped on this shaft, a quarter turn of which releases the keel.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.*

PHOSPHORUS EMANATION.—Ordinary gaseous ions have the faculty of condensing vapor when sufficiently supersaturated. They have a velocity of the order of 1 centimeter per second in a field of 1 volt per centimeter. Electrolytic gases contain, according to Townsend, ions of a mobility 300 times less than the above, but are able to condense simply saturated vapor. These exceptional ions may be compared to the ions produced in air when perfectly dry air passes over phosphorus. E. Bloch shows that the uncertainty of experiments in this connection disappears as soon as care is taken to use none but perfectly dry air. That there are true ions present is proved by the fact that if the ionized air is made to pass through a strong electric field, the ions are completely absorbed. The author has, therefore, applied Zeleny's method of measuring the mobility by means of a current of the ionized air blown between two condenser plates, and has found that the ions due to phosphorus emanation have the same mobility as the ions of electrolytic gases—viz., 1-300 millimeter per second. There is, however, a characteristic difference. The latter class of ions can only condense saturated vapor, but the phosphorus emanation is capable of condensing unsaturated vapor. —E. Bloch, Bull. Soc. Fr. de Phys., No. 190, February 20, 1903.

RADIO-ACTIVITY NEAR WATERFALLS.—Since Elster and Geitel produced radio-active substances by exposing a negatively-charged wire to the atmosphere, the influence of varying atmospheric conditions upon this process has acquired considerable interest. Lenard showed that very anomalous electric conditions hold at the foot of Niagara Falls, where the impact of the water upon the rocks gives the water a positive and the spray a negative charge. This circumstance suggested to J. C. MacLennan the expediency of studying the radio-activating process at the foot of the falls. The general result of the investigation was that the radio-activity acquired under those abnormal conditions was very much smaller than that acquired under ordinary circumstances at Toronto. The measurements were made with a copper wire carried on ebonite insulators, and charged to 10,000 volts by means of a Toepfer-Holtz machine. The radio-activity was compared with that produced by a standard radium preparation. The greatest radio-activity obtained at Niagara was 0.3, and the least at Toronto was 0.6, but, as a rule, the Toronto values were six or seven times as high as the Niagara values. The wire always got charged at once by the spray, sometimes to 7,500 volts. —J. C. MacLennan, Physikal. Zeitschr., February 15, 1903.

RADIUM IN THE PERIODIC SYSTEM.—C. Runge and J. Precht have succeeded with the aid of a few milligrammes of radium bromide in obtaining a complete radium spectrum and in photographically determining

the behavior of the brightest lines in the magnetic field. They find that the brightest radium lines correspond strictly with the strongest barium lines and the analogous lines of magnesium, calcium, and strontium. According to Runge and Paschen, the strongest lines of the alkaline earths may be arranged in pairs belonging to three series which they call the main series, the first side series, and the second side series respectively. In the scale of frequencies each pair has the same distance apart for a given element, but this distance varies from one element to another, and if curves are constructed having the logarithms of the atomic weight and the distance apart as co-ordinates, the points representing chemically allied elements lie on the same straight line. Radium has a place on the Mg-Ca-Sr-Ba line. But its atomic weight would have to be 257.8 instead of 225 as claimed by Mme. Curie. The authors attribute the discrepancy to barium impurities. In the magnetic field, the radium line 4826.14 shows exactly the same Zeeman effect as the corresponding lines of Ca, Sr, and Ba.—Runge and Precht, Physikal. Zeitschr., February 15, 1903.

ELECTRICAL NOTES.

A striking feature of the electrical industry has been the increase in the number and importance of the plants owned and operated by municipalities. In 1902 the city and town governments operated 22.5 per cent. of all central electric stations, and the horse power of their power and generating plants formed 8.9 and 9.4 per cent., respectively, of the total power reported for all stations. The output of municipal stations was 8 per cent. of the total kilowatt hours reported for all stations in operation, and their arc and incandescent lamps wired for service formed 13.2 and 8.7 per cent., respectively, of all lamps.

On the Chelsea branch of the Philadelphia Railroad to Atlantic City a new surface contact transportation system was tested on a mile of track. The inventor is Leon W. Pullem, a young electrician of Philadelphia. A large trolley car was used for the experiment, and over one hundred people were crowded in it. Beneath the car is attached a series of magnets, which make the contact as the car passes over the boxes, which are in the center of the tracks, 16 feet apart. In appearance the contacts are like inverted saucers, and are alive only at the time of the passage of the car over them. It is claimed that a speed of eighty miles an hour can be attained.

The use of automatic cardcutting machines in connection with textile patterns has been much sought after in recent years, and there have been a large number of attempts to utilize electricity in the process. The ordinary process of cutting these cards in the piano machines, with foot power for driving the punches, takes a considerable time, and is none too accurate unless highly skilled operators are employed. We understand that a Bradford syndicate have been developing a machine designed by an Austrian engineer named Zerkowitz, and that they have succeeded in turning out an electrical cardcutting machine on the following lines: The machine works on the principle which has been often tried before, but which has previously failed, due to troubles of a practical nature. The design is painted on a metal surface with some non-conducting material, and then a number of pins resting on the plate determine which of the punches shall operate. The actual details of the machine are not before us, but we understand that it enables the design to be cut at the same time as the groundwork, and that the speed is at least ten times greater than by previous methods of cardcutting.

At the present time, when the commercial application of the Elmore patents for the manufacture of copper tubes by electrolysis is assuming extensive proportions, it will not be without interest to give a short account of the present position of the process. According to the Electro-Chemist and Metallurgist, the process emanated from patents by Stanley and Frank Elmore, and is shortly as follows: The positive pole of a dynamo is connected to an anode of raw granulated or block copper laid at the bottom of a pitched wooden vat containing an acidulated solution of copper sulphate. About 1.2 inch away from this anode a copper or iron cylinder, forming the cathode and connected to the negative pole of the dynamo, is rotated at a suitable speed. In order to give the copper thus deposited on this cylinder or mandrel a firm and dense structure, and to prevent any crystalline forming, an agate burnisher travels up and down the length of the cylinder and exerts a constant pressure on the surface; and as the conditions are regulated in such a way that the layer at any point only increases in thickness by some 0.0013 inch before the agate brush has again returned there, the depositing copper is obtained in a homogeneous state. A comparatively light current density, 56 amperes per square foot, is employed, so that the deposition of a copper tube 0.2 inch thick would take just under a week. With ordinary processes of copper refining, the current density employed is about a tenth of the above. When the deposited tube has attained the desired thickness, it is stripped from the mandrel and is ready for the market. Tubes of small diameter are comparatively more expensive to manufacture by the process, so that the German Elmore Company turn their attention more particularly to those of larger diameter. As an example of this, our contemporary illustrates what is claimed to be the biggest seamless copper tube in the world, which was manufactured by the Elmore process and exhibited at the Düsseldorf Exhibition. It was designed for a condenser cover, and weighs 7,940 pounds, is 16.4 feet long, 8.2 feet in diameter, and has a thickness of 0.39 inch. The copper obtained by the Elmore process has very satisfactory mechanical properties. For example, a tube of 11.8-inch diameter and 0.12 inch thick, when subjected to hydraulic pressure, expanded to 13 inches at 14 atmospheres, and did not finally burst until the pressure had reached 52 atmospheres. At present there exist three Elmore works—one at Schlader, in Germany, one at Leeds, in Eng-

* Compiled by E. E. Fournier d'Albe in the Electrician.

land, and one at Havre, in France—having a total weekly capacity for producing 396,000 pounds of copper, and a total amount of power available amounting to 5,600 horse power.

THE EXCAVATION AT GIGTHIS.

The soil of Tunis, covered at the time of Phœnician power and of the Roman occupation with flourishing cities, is gradually giving up its treasures to our savants. For the past three years the archaeological service of Tunis has devoted a great part of its energy to bringing to light some of the edifices and principal quarters of Gigthis, with the courteous aid of the officers of the service of indigenous affairs and with the manual labor of the military prisoners. The first results exceeded all expectations. The fact alone of this task having been undertaken seems sufficiently bold when we reflect that the vestiges of Gigthis are situated in the extreme south of the regency, at the back of the gulf of Bou-Grara, to the south of the island of Djerba, in the confines of Tripolitania, in a region that a few years ago was considered dangerous.

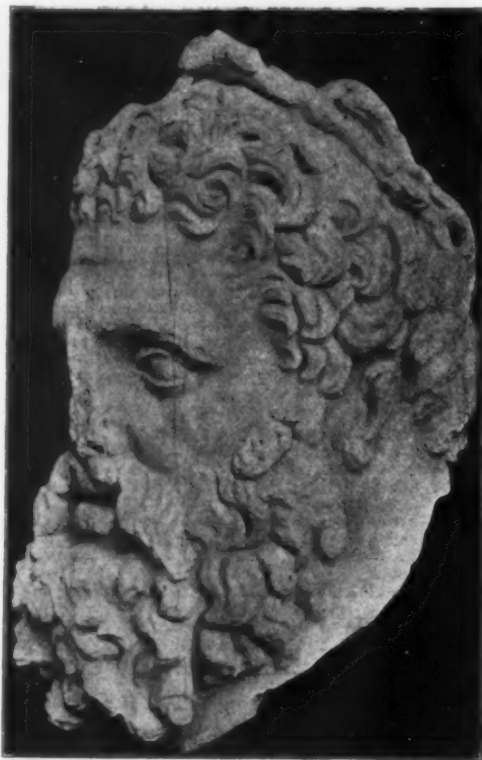
Gigthis may be considered as the type of the *emporion* of Phœnician origin, and the great market town of the region of the Syrtes. Established by the Carthaginians, enlarged by the Romans and highly favored by the generosity of the Antonines, who made a municipality of it, the past seems, according to the story told by its stones, to have reached its greatest prosperity toward the end of the second century of our era. In this vast caravansary, a hundred different peoples touched elbows; leaders of caravans carrying their valuable loads of gold dust and ivory from the Soudan and Pentapolis; merchants of the coast which was then so animated; Jewish or Carthaginian contractors, mingled with Greek sailors and Roman soldiers and officials; and a host of Nigritian slaves, etc.

The city was situated upon a gently sloping hill, bounded on the side toward the sea by high cliffs. The port, filled at present by sand, was small, but of sufficient depth for war and merchant vessels of the heaviest tonnage. Contrary to what happens with the European Mediterranean ports, it was now filled with water and now dry, according to the tides, which are very strong in the region of the Syrtes. The sirocco and atmospheric erosions have, moreover, considerably modified the relief of the land by forming depressions and making the elevations more pronounced. The center of the Roman city was first attacked at the place where the principal public structures were grouped. The forum, established in proximity to the shore, upon an eminence overlooking it, consists of a vast rectangular esplanade of 197 x 131 feet, fronting the sea. It is reached on the east by a paved road that ascends the hill at a slight gradient by a succession of landings one above another that connect a number of stairways, and which passes beneath a triumphal gate of which the arch and dedications have been found.

At the rear of the square stands the Capitoline temple, which, through its architectural arrangements, somewhat recalls that of Pompey. It is flanked by two richly ornamented edifices that occupy the angles of the forum, and one of which seems to have been the city treasury. Here, set into a wall of remote epoch, was found a colossal head of Jupiter Serapis. Upon the three other sides, on the north, south, and east, extends a portico with Corinthian columns, upon which open various sanctuaries and public structures. On the south there is a vast hall in which were found the head and several fragments of a statue of Augustus. On the north, a chapel in front of which was discovered a dedication to the divine Commodus, a structure that sheltered a brass basin, a temple of Apollo, a Pantheon preceded by a *pronaos*, at the rear of which lay a statue of the Concordia Panthea, overturned at the very place that it formerly occupied under a structure with triangular pediment, a small temple with colonnade and rostrum, which, from the data furnished

bordered on three sides by a portico with colonnades, all the bases of which are still in place. A pedestal standing in the center of the court seems to have supported a bronze statue, some fragments of which were found. At the south there is another building provided with a rostrum with staircase. It was doubtless the basilica with the *prætorium*.

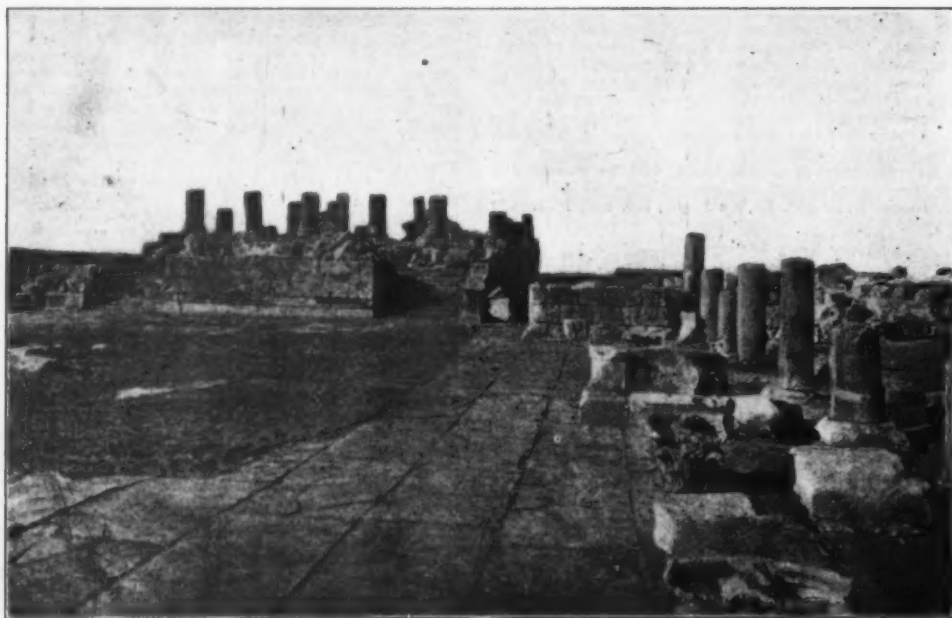
Valuable data relative to the date of these edifices are furnished by the dedications engraved upon the



HEAD OF A COLOSSAL STATUE OF HERCULES FOUND IN A SMALL TEMPLE.

marble slabs over the entrance door or upon the pediment of the façade, and that were found in small fragments amid the rubbish.

By the number and importance of the inscriptions that concern it, the forum of Gigthis stands in the first rank of analogous monuments. It offers no less interest from a purely architectural standpoint. Constructed in the middle of the second century of our era, nearly at the same epoch as that of Timagad, it is just as long and complete as that, and of a richer ornamentation. The most valuable marbles and the most varied tones were employed to profusion for the colonnades, the inlaid work, the statues, and the pedestals. Bas-reliefs of marble or stucco ornamented the façade of the principal edifices, the roofs of which were bordered with acroteria of palm-leaves, and the walls adorned with frescoes. Such architectural decoration, conceived in very fine taste and bearing the mark of Hellenic genius, has left numerous vestiges which have been collected with care in the ruins and safely carried to the Bardo Museum at Tunis.



THE TEMPLE OF THE CAPITAL SEEN FROM THE FRONT.

by its dedication must have been decorated with paintings, and, finally, another sanctuary sheltering a colossal statue of Hercules, the head of which, 20 inches in height, was found almost intact.

At the east and in front of the forum, on one side and the other of the triumphal gate, are two larger edifices; to the north a temple, probably the curia of the municipium, preceded by a rectangular peribolus

It is, however, not only the forum that has been restored, but the principal wards of the city have been found in their broad lines, with their main streets, their public places, their alleys and their edifices. Upon extending the researches still further, outside of the city, a luxurious villa was unearthed. The apartments of this large country house were distributed around a central rectangular peristyle bordered by a portico

with colonnades that is still adorned with a beautiful mosaic.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Le Monde Illustré*.

SCIENTIFIC POTATO CULTIVATION IN GERMANY.

By United States Consul-General MASON, Berlin, Germany.

In a recent report, "The Potato as a Source of Wealth in Germany" (Advance Sheets No. 1599, March 20, 1903), the statement was made that potato cultivation in this country has been advanced by systematic and careful experiment to a high standard of efficiency. In response to the expressed desire of certain American agriculturists for some account of the methods employed here for securing maximum yield and high quality of product, the following report is respectfully submitted:

Potato cultivation, like all farming on a large scale in Germany, is based on an exact knowledge of the soil. This includes not only the elements which it contains, but its underlying strata, exposure, elevation, and surroundings, whether shaded by adjacent woodlands or buildings, and especially its susceptibility to natural efficient drainage. There is no careless, hit-or-miss guesswork as to what the soil may lack or what it contains. The agricultural and technical schools of Germany have trained an army of practical chemists, expert in the analysis of soils and familiar with the elemental requirements of every plant known to German husbandry. The effective value of every kind of fertilizer, its influence on crops planted in sand, clay, or loam, and the efficacy of clover, lucern, and other growths when plowed in to enrich soils in nitrogen are accurately known. The Ministry of Agriculture, through its system of experimental stations, has worked out the whole problem of varieties, soils, methods of planting, cultivation, and harvesting; the farmer has only to follow the methods that modern science has made easy and plain, and with reasonably favorable sunshine and rainfall his result is secure.

THE INFLUENCE OF VARIOUS SOILS.

Although the potato will grow in every arable field in Germany, from the upper hill slopes to the moorlands of the valleys and seacoast, there is a wide variation, both as to quantity and quality, in the product of the different localities. Poor, light, gravelly soils yield small and few potatoes, and in dry seasons fail altogether. Heavy, tough, cold clays are likewise unfavorable. The ideal potato land is a warm, permeable, loamy sand or a light moorland, well drained, clean, and rich from the vegetable decay of past ages. Soils containing large proportions of sand produce potatoes of the best flavor and with highest percentage of starch. So marked are these characteristic effects that in every potato market of Germany the products of certain communes are known and rated at the head of the list, because the soils of those districts have demonstrated their superior fitness for potato culture. A potato field should be open, fully exposed to sun and wind, not shaded or obstructed by trees, and above all free from clay substrata which hold water and make a wet subsoil. Crops grown on land with these defects may in some seasons be large, but they rot easily and are always deficient in starch and of inferior flavor. In Germany the red and so-called "blue-skinned" potatoes are found to do better than the white in damp locations or where the land is excluded from free action of sun and wind.

PREPARATION OF THE SOIL.

In the preparation of land for potato planting the first requisite is deep, thorough plowing. In view of the many centuries during which the fields of Germany have been cultivated, and the generally high standard of intelligence among farmers here, an American is surprised to note that in many wheat, rye, and oat fields the plow does not cut more than 6 or 7 inches in depth. But for potatoes this superficial scratching of the earth will not suffice. Every additional inch of depth broken up adds a tangible percentage to the yield, and on the best farms subsoil plowing attains a depth of 12 to 15 inches. Small tracts are worked with the spade, and instances are given where the potato crop has been doubled by working the soil two spade lengths in depth. This deep, careful preparation of the land is always completed in autumn, and the upturned earth left exposed to the action of frost and thawing during the winter. Careful experiment has shown that a given piece of land prepared in autumn yields one-third more potatoes than if treated in precisely the same manner in spring immediately before planting time. Having been deeply plowed and thoroughly harrowed in autumn, the frost penetrates readily, the action of the air upon the various elements of the soil is enhanced, it dries out quickly in spring, and with the first warm days is ready for planting.

PLANTING.

It is then plowed again, usually to a depth of 5 or 6 inches, with a broad, shallow plow drawn by one horse, and in every third furrow the potatoes are dropped and are covered by the furrow slice next turned in. This quick, easy method of planting with the plow is practicable only in light, loose soils that have been thoroughly prepared.

In heavy clay soils holes 5 or 6 inches deep are made in rows with the hoe or spade, the potatoes dropped therein and covered with the hoe. Still another method of planting is to mark out the land in squares by crosshatching with a "Reihenzieher," or marking plow, which draws three shallow lines or furrows. A potato being planted at each intersection of these lines and covered with the hoe grows in separate plants or "hills" which can be worked both ways with the small plow or cultivator, though the usual method in Germany is to plant potatoes in rows which are in line and can be worked by horse implements in only one direction. In the light, sandy soils of Germany it is found advantageous to press down the earth over the seed potato with the foot or otherwise, to prevent too rapid drying out of the soil under the

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spring sunshine. Whatever method of planting is employed, great care is taken that all the seed potatoes shall be covered to a uniform depth. Experiment has shown that an inch or two more or less of superincumbent soil will make an important difference in the character of the plant and its product. When planted too deep the plant grows in long, slender stems which remain green too late in autumn and produces only a few small tubers at their roots. The proper depth is a matter of judgment for the experienced

on them the danger of rot in the growing tubers is greatly increased. Experiments conducted by Prof. Marek at Königsberg show that the richer the seed potato is in starch the more proper nutriment it affords to the infant plant and the larger will be the resulting yield. Another point of prime importance is the change of varieties of seed.

Of all agricultural crops, the potato is one of the most amenable to the principle evolved by Darwin—that plants, animals, and even men, when reproduced

the spread and vigor of the roots. The first hoeing takes place about five weeks after planting and when the plants are so far above ground that the rows can be readily recognized. Besides the common hoe, German farmers use a three-pronged fork with wide tines and with a handle like a hoe. This being driven into the ground near the roots of the plant, the laborer is enabled by a prying movement to so lift and loosen the soil that the air is admitted. The second hoeing takes place two weeks later, at which time the mound, or "hill," around the plant is formed, and a fortnight later still the final "hilling up" is done with small plow, horse hoe, and by hand. If the potatoes have been planted at proper depth it is not necessary, but rather disadvantageous to build the hill too high. Much depends, of course, on the nature of the soil, something on the variety of the potato itself, but still more on the weather. In a wet season the hills should be proportionately higher than when the ground is dry. It remains to consider finally the question of

FERTILIZERS AND THE PREPARATION OF POTATO LAND.

This, from the standpoint of German agriculture, is by far the most complicated and important portion of the subject. The three essential elements to be provided by artificial fertilization are phosphoric acid, potash, and nitrogen. The first is obtained through the application of mineral phosphate, Thomas slag phosphate meal, or bone dust. Thomas meal is applied in the proportion from 1,000 to 1,200 pounds per acre, but being sparingly soluble it acts very slowly on the growing crop and in dry seasons hardly at all. It is most effective in moist soils and in seasons of abundant rainfall. Steamed bone dust is used—300 to 400 pounds per acre—by being strewn over the land in late autumn and plowed in. Superphosphate fertilizers are used in the spring and are deposited and covered with the seed at planting time. Far more important, however, for potato culture are the potash-bearing fertilizers. These are plentiful and cheap in Germany in the form of kainite and carnallite minerals from the mines of the Stassfurt district, near Magdeburg. The enormous development of potato production in this country during the past thirty years has been due to no other fact so potent as the exclusive possession of an unlimited supply of potash minerals. Many of what are now the best potato lands were twenty years ago deficient in potash for the reason that the potato consumes that element in large proportion, so that the original natural supply had long been exhausted by ignorant, unskillful cultivation. What was needed was to restore the exhausted potash. But it was found that neither kainite nor carnallite—both of which contain traces of chlorine—could be used raw and directly as a manure for the growing crop without impairing the flavor and quality of the potato. To produce the best effect these mineral fertilizers have to be digested and assimilated with other elements in the soil. To secure this result they are applied during the preparatory process, one or two years before the land is planted to potatoes, and serve to nourish the clover, the lupine, or other fallow crops that are grown and plowed under as manure. By this method the potash salts are not only digested, purified from chlorine, and mingled thoroughly with the soil, but it is enriched by the nitrogen of the buried vegetation and prepared for the abundant growth of potatoes of the highest quality, rich in starch and of standard flavor.

Nitrogen is applied in the form of stable manure worked into the soil during the one or two years previous to potato planting and of Chile saltpeter, which, as already described, is used as a top dressing applied directly while the plants are growing. Chile saltpeter covered in the earth either leaches away into the subsoil or forms insoluble combinations with



MOSAIC PAVED PASSAGEWAY OF A SUBURBAN VILLA OF GIGTHIS.

farmer and varies from 10 centimeters (4 inches) in light, sandy soils to 3 inches for loam and 2 inches for heavy clay or moorlands. For the same reasons, care and judgment are required in cultivating or "hilling up" the plants to bank them up with sufficient earth to preserve the moisture at the roots, but not to smother the plant by putting too much of its length of stems underground. Early varieties, which reach their maturity the end of summer, are planted more closely together than the later sorts, which form the bulk of the potato crop and are harvested in October and November. While it is therefore difficult to formulate an exact rule that will fit the different varieties of potatoes and varying soils, the general principle is that in potato culture on a large scale one potato plant, or "hill," is allowed 4 square feet of space. If the rows are to be cultivated by horse implements in both directions they are set 2 feet apart. If, as is more usual, they are to be worked in one direction the seed potatoes are laid 12 or 15 inches from each other in rows 3 feet apart. In light soils this interval may be reduced to 2 feet, and for very early varieties to even less.

THE QUANTITY OF SEED TO BE PLANTED.

The quantity of seed to be planted depends upon the size of the potatoes planted, the variety, whether early or late, and somewhat also upon the strength and depth of the soil. The Prussian "Morgen," or unit of land measure, is one-fourth of a hectare, which latter is equivalent to 2.471 acres. The average allowance of seed potatoes, subject to variations in deference to the above conditions, is 2,000 kilogrammes (4,408 pounds avoirdupois) per hectare, or about 1,780 pounds per acre. Experiments have been made at the agricultural testing stations with all quantities of seed, from 1,800 to 2,500 kilogrammes (3,967 to 5,510 pounds) per hectare, with the general result of somewhat increasing the seed allowance, so that on many highly cultivated and progressive farms the proportion is as high as 2,200 kilogrammes per hectare, or 1,960 pounds per acre. Whatever the quantity planted and at whatever intervals the rows or hills may be placed, the German farmer who knows his business plants only large, full-grown, healthy potatoes. Every attempt to economize in seed by using small, inferior, and therefore unmarketable potatoes has resulted in the further deterioration of the crop, and, if continued, in disaster to the farmer. Here, too, the long-continued, careful tests of the agricultural experiment stations have produced some surprising proofs of the value of large, perfect potatoes for seed purposes. Not that the very largest are, however, necessary. On well-managed farms in Prussia potatoes when harvested are frequently assorted into four grades of sizes, viz., (1) very large, (2) full-sized and perfect in form and condition, (3) medium, and (4) small. Under this division grade 1 brings the highest price in the market, grade 2 is used for seed and is also salable for food, while grades 3 and 4 go mainly to the distilleries, the starch and dextrin factories, or in seasons of great abundance are fed to hogs and cattle. Seed potatoes are usually planted whole, not cut, as is often done in the United States and other countries. The verdict of scientific experiment is that cutting the seed potato impairs the vigor of the plant, which in its earliest stage of growth feeds upon the substance of the tuber, but all accounts agree that large potatoes cut into sections are much better than small ones planted whole. Before planting, the seed potatoes are taken out of the cellars or buried heap where they have been kept through the winter and thoroughly dried in a cool, airy place. If planted with the damp of winter still

under the same conditions from generation to generation, lose something of their original vigor and fecundity. The unfavorable results of "inbreeding" in families and races of animals are entailed in the degeneration of potatoes which are grown year after year from seed raised in the same location. The scientific German farmer rarely plants seed potatoes from his own fields, but exchanges with his neighbor or obtains new varieties from the experiment station or a more or less remote district. The more radically different the conditions of the new locality are from those in which the seed potato was grown the greater seem to be the benefits wrought by the change. Potatoes grown on high hill slopes are brought down and planted in valleys; the product of heavy, wet land is planted in light, dry soils; the growth of sandy fields is the best seed for loam or moorland; and vice versa. Potatoes brought from Scotland have produced some of the largest and best crops ever grown in Germany.

PROCESS OF CULTIVATION.

The process of cultivation begins about three weeks after planting and just as sprouts begin to appear



THE FORUM OF GIGTHIS SEEN FROM THE NORTHEAST.

above the surface. The field is then worked carefully with a light harrow or cultivator, which opens up and mellowes the soil and destroys the weeds and grass which have begun to appear. At the same time a top dressing of Chile saltpeter (100 pounds to the acre) is added, the fertilizing material being strewn along the rows close to the growing plants. It has been found that nitrogen applied directly at that stage of growth has an immediate and important effect upon

other elements and is thereby lost to the farmer. Used as a top dressing it has an immediate and often important effect in reviving and stimulating a crop, but it should never be applied to the soil in autumn nor in the spring before the potato sprouts have appeared above ground.

Reduced to its simplest terms, the secret of German pre-eminence in potato cultivation consists in the careful, patient scientific preparation of the soil, not only

by the restoration of its exhausted elements, but by mellowing, enriching, and revivifying it by deep cultivation and the plowing in of green manure crops, which have taken up and digested the crude mineral fertilizers. Land thus prepared will yield three or even four crops of potatoes before their quantity or quality will begin to deteriorate. In extreme cases, where a small farmer can not advantageously raise any other crop, he may continue to plant potatoes on the same ground ten or twelve years, but good husbandry dictates that as a principle a change to cereals, beets, or clover is advisable after the fourth successive season of potatoes.

THE QUESTION OF VARIETIES.

The question of varieties is also of importance, but the subject is so diffuse that any adequate consideration of it would far transcend the limits of a consular report. The prospectus of a standard dealer in seed potatoes, which is transmitted as an exhibit with this report, includes 100 different varieties of potatoes, all meritorious and more or less specially adapted to each peculiar condition of soil, exposure, or purpose for which the product is to be used. Certain varieties excel for food purposes, others as material for starch and dextrin, still others for desiccation and distillation in the production of alcohol, and yet others for stock-feeding purposes. Many of the most valuable sorts for general purposes are of recent origin. There are dozens of skillful and experienced growers in Germany who give their whole time and energy to the propagation of improved varieties of potatoes, and samples of their products weighed, analyzed, and labeled with the place and all conditions of growth formed a large and interesting feature of the exhibition last February. As long ago as 1863 not less than 500 varieties of potatoes were catalogued and known in this country. Many of them have disappeared from the catalogues of to-day, and the real crop of practical growers is limited to not more than 20 standard sorts which have stood the tests of varying seasons, diverse soils, and the multifarious uses to which the potato is now applied in Germany.

[Concluded from SUPPLEMENT No. 1458, page 23363.]

THE ATOMIC THEORY.*

LET US now turn back in time, and consider another phase of our subject. In 1815 Prout suggested that the atomic weights of all the elements were even multiples of that of hydrogen. It was only a speculation on the part of Prout, and yet it led to important consequences, for it opened a discussion upon the nature of the chemical elements, and it pointed to hydrogen as a primal matter of the universe. Prout's hypothesis, therefore, became a subject of controversy; it found many supporters and also many antagonists; but, fortunately, one aspect of it was capable of experimental investigation. Some of the most exact and elaborate determinations of atomic weight have been made with the direct purpose of testing the truth or falsity of Prout's speculation, and science thereby has been notably enriched. The marvelous researches of Stas, for instance, had this specific object in view. The verdict was finally unfavorable to Prout; at least, the best measurements fail to support his idea; but it still has advocates who believe that the experimental data are vitiated by unknown errors and that future investigation will reverse the decision. In science there is no court of last appeal.

Prout's hypothesis, then, stimulated the determination of atomic weights, and so helped us to a more accurate knowledge of them. It also led to a search for other relations between these constants, and thus paved the way for important discoveries. Döbereiner, Kramers, Dumas, Pettenkofer, Cooke and many other chemists published memoirs upon this theme, but not one of them was general or conclusive. Groups of elements were compared and relations were brought to light, but an exhaustive study of the question was hardly possible until after Cannizzaro had revised the atomic weights and indicated their proper values.

In 1865, Newlands presented before the London Chemical Society a communication upon the law of octaves, in which he showed that the elements, when arranged in the order of their atomic weights, exhibited a certain regular recurrence of properties. Unfortunately, his views were not given serious attention, and even met with ridicule, but they contained the germ of the great truth. It was reserved for the Russian, Mendeleeff, four years later, to completely formulate the famous periodic law.

Mendeleeff arranged the elements in tabular form, still following the order of their atomic weights. A periodic variation of their properties, including the property of valency, at once became evident; and although the scheme was, and still is, open to some criticism, its importance could hardly be denied. In the table, certain gaps appeared, presumably belonging to unknown elements, and for three of these some remarkable predictions were made. The hypothetical elements were described by Mendeleeff, their atomic weights were assigned and their physical properties foretold, and in due time the prophecies were verified. The three metals gallium, scandium, and germanium have since been discovered, and they correspond very closely with Mendeleeff's anticipations. His general conclusion was that all of the physical properties of the chemical elements are periodic functions of their atomic weights, and this conclusion, I think, is no longer seriously doubted. The curves of atomic volumes and melting points which Lothar Meyer afterward constructed give strong support to this view.

The periodic system, then, gives to the numbers discovered by Dalton a much more profound significance than he ever imagined, and is destined to connect a great mass of physical data in one general law. That law we now see, "as in a glass, darkly;" its complete mathematical expression is yet to be found, but I believe that it will be fully developed within the near future. We may have a spiral curve to deal with, as

in the schemes proposed by Stoney or by Crookes, or else a vibratory expression like that suggested by Emerson Reynolds in his presidential address before the Chemical Society last year; but in some form the periodicity of the elements must be recognized, and one set of relations will connect them all. In the arrangements proposed by Reynolds the inert gases, the elements of zero valency, appear at the nodes of a vibrating curve, a circumstance which gives this method of presentation a peculiar force. But for the consideration of physical properties the curves drawn by Lothar Meyer seem likely to be the most useful. In one respect, however, the periodic system is still defective; it fails to take adequately into account the numerical relations between the atomic weights, a phase of the problem which should not be ignored. Such relations exist; some of them have been indicated by your distinguished fellow member, Dr. Wilde; and, elusive as they may seem to be, they are surely not meaningless. The final law must cover the entire ground, and then atomic weights, physical properties and valency will be completely correlated. Prout's hypothesis is discredited, and yet it may prove to be a crude first approximation to some deeper truth, as the probability calculations of Mallet* and of Strutt† would seem to indicate. The approaches of the atomic weights to whole numbers are too close and too frequent to be regarded as purely accidental. But this is aside from our main question. The real point to note is that the physical properties of the elements are all interdependent, and that the fundamental constants are the atomic masses.

Do I seem to exaggerate? Then look for a moment at the present condition of physical chemistry, and see how moderate my statements really are. We have not only the laws already mentioned, of Avogadro, of Dulong and Petit, of Faraday and of Mendeleeff, but also a multitude of relations connecting the physical constants of bodies with their chemical character. Even the wave-lengths of the spectral lines are related to the atomic weights of the several elements, as has been shown by the researches of Runge and his colleagues, of Rummel,‡ and of Marshall Watts.§ If we try to study the specific gravity of solids or liquids, the only clues to regularity are furnished by the atomic ratios. Atomic and molecular volumes give us the only approximations to anything like order. Similarly, we speak of atomic and molecular refraction, of molecular rotation for polarized light, of molecular conductivity and the like. In Trouton's law, the latent heat of vaporization of any liquid becomes a function of the molecular weight. And, finally, all thermochemical measurements are meaningless until they have been stated in terms of gramme molecular weights; then system begins to appear. Chaos rules until the atomic or molecular weight is taken into account; with that considered, the reign of order begins.

Even to the study of solutions the same conditions apply. Substances in solution exert pressure, and in this respect they closely resemble gases. Van't Hoff has shown that equal volumes of solutions having, under like conditions, equal osmotic pressures, contain equal numbers of molecules, and thus Avogadro's gas law is curiously paralleled. The two laws are even equivalent in their anomalies. The abnormal density of a gas is explained by its dissociation, and the variations from Van't Hoff's law are explicable in the same way. The theory of ionic or electrolytic dissociation, proposed by Arrhenius, shows that certain substances, when dissolved, are split up into their ions, and through this conception the analogy between gases and solutions is made absolutely complete. The ions, however, are atoms or groups of atoms; and just as Avogadro's law is applied to the determination of molecular weights among gases, so Van't Hoff's rules enable us to measure the molecular weights of substances in solution. The atom, the molecule, and the molecular weight enter into all of these new generalizations. In short, if we take the atomic theory out of chemistry, we shall have little left but a dust heap of unrelated facts.

I have now indicated, briefly and in outline only, the influence of the atomic theory upon the development of chemical thought. Details have been purposely omitted; the salient facts are enough for my purpose, and they make, at least for chemists, an exceedingly strong case. The convergence of the testimony is remarkable, and when we add to the chemical evidence that which is offered by physics, the theory becomes overwhelmingly strong. This side of the question I cannot attempt to discuss, but I may in passing just refer to Prof. Ricker's presidential address before the British Association in 1901, which covers the ground admirably. The atomic theory has had no better vindication.

And yet, from time to time, we are told that the theory has outlived its usefulness, and that it is now a hindrance rather than a help to science. Some of the objectors are quite dogmatic in their utterances; some only seek to evade the theory, without going to the extreme of an absolute denial; and still others, more timid, assume an apologetic tone, as if the atom were something like a poor relation, to be recognized and tolerated, but not to be encouraged too far. Now caution is a good thing, if it is not allowed to degenerate into indecision; when that happens, mental obscurity is the result. In science we must have intellectual resting places; something to serve as a foundation for our thinking; something concrete and tangible in form. No theory is immune against hypercriticism; none is absolute and final; with these considerations borne in mind we may ask whether a doctrine is serviceable or not, and we can use it without fear. When we say that matter, as we know it, behaves as if it were made up of very small, discrete particles, we do not lose ourselves in metaphysics and we have a definite conception which can be applied to the correlation of evidence and the solution of problems. Objections count for nothing against it until something better is offered in its stead, a condition which the critics

of the atomic theory have so far failed to fulfill. They give us no real substitute for it, no other working tool, and so their objections, which are too often metaphysical in character, command little serious attention. Criticism is useful just so far as it helps to clarify our thinking; when it becomes a mere agent of destruction it loses force.

Broadly speaking, then, the modern critics of the atomic theory have shaken it but little. Still, some serious attempts have been made toward forming an alternative system of chemistry, or at least a system in which the atom shall not avowedly appear. The most serious, and perhaps the most elaborate of these devices was that brought forward in 1866 by Sir Benjamin Brodie,* in his "Calculus of Chemical Operations," which he defended later (1880) in a little book entitled "Ideal Chemistry." In this curious investigation, Brodie tries to avoid hypotheses and to represent chemical acts as operations upon the unit of space by which weights are generated. This notion is a little difficult to grasp, but Brodie's procedure was perfectly legitimate. His one fundamental assumption is that hydrogen is so generated by a single operation, and upon this he erects a system of symbols which, treated mathematically, lead to some remarkable conclusions. For instance, chlorine, bromine, iodine, nitrogen, and phosphorus become compounds of hydrogen with as many unknown or "ideal" elements which no actual analysis has yet identified. That is, the known phenomena of chemistry seem to be less simply interpreted by Brodie's calculus than in our commonly accepted theories, and certain classes of phenomena are not considered at all. It is true that Brodie never completed his work, but it is not easy to see how his notation and reasoning could have accounted for isomerism, much less for the facts which stereochemistry seeks to explain.

Just here we find the prime difficulty of all attempts to evade the atomic theory. Up to a certain point we can easily dispense with it, for we can start with the fact that every element has a definite combining number, and then, without any assumptions as to the ultimate meaning of these constants, we can show that other constants are intimately connected with them. So far, we can ignore the origin of the so-called atomic weight; but the moment we encounter the facts of isomerism or chemical structure, and of the partial substitution of one element by another, our troubles begin. The atomic theory connects all of these data together, and gives the mind a simple reason for the relations which are observed. We cannot be satisfied with mere equations; our thought will seek for that which lies behind them; and so the anti-theorist fails to accomplish his purpose because he leaves the human mind out of account. The reasoning instrument has its own laws and requirements, and they, as well as the empirical observations of science, must be satisfied. Even in astronomy the law of gravitation is not enough; men are continually striving to ascertain its cause; and no number of failures can prevent them from trying again and yet again to penetrate into the heart of the mystery. In the atomic theory the same tendency is at work, and the very nature of the atom itself, that thing which we can neither see nor handle, has become a legitimate subject for our questionings. Shall we, having gone so far, assume that we can go no farther?

"All roads lead to Rome." If we accept the atomic theory, we sooner or later find ourselves speculating about the reality of the atom, and at last we come face to face with the old, old problem of the unity or diversity of matter. We can, if we choose, employ the theory as a working tool only, and shut our ears to these profounder questions; but it is not easy to do so. What is the chemical atom? Is all matter ultimately one substance? We may be unable to solve either problem, and yet we can examine the evidence and see which way it points.

I think that all philosophical chemists are now of the belief that the elements are not absolutely distinct and separate entities. In favor of their elementary nature we have only negative evidence, the mere fact that with our present resources we are unable to decompose them into simpler forms. On that side of the argument there is nothing more. On the other hand, we see that the elements are bound together by the most intimate relations, so much so that unknown elements can be accurately described in advance of their discovery, and facts like these call for an explanation. Something belonging to the elements in common seems to underlie them all. If, however, we study the atomic weights, we are forced to observe that the elements do not shade into one another continuously, but that they vary by leaps which are sometimes relatively large, and sometimes quite small. To Mendeleeff this irregular discontinuity is an argument against the unity of matter, or, rather, an indication that the periodic law lends no support to the belief; but such a conclusion is unnecessary. If the fundamental matter, the "protyle," as Crookes has called it, is itself discontinuous and atomic in structure, the same property must be shown in all of its aggregations, and so the difficulties seen by Mendeleeff disappear. The chemical atoms become clusters of smaller particles, whose relative magnitudes are as yet unknown.

That bodies smaller than atoms really exist is the conclusion reached by J. J. Thomson† from his researches upon the ionization of gases. According to him, this phenomenon "consists in the detachment from the atom of a negative ion," this being "the same for all gases." He regards "the atom as containing a large number of smaller bodies," which he calls "corpuscles," and these are equal to one another. "In the normal atom this assemblage of corpuscles forms a system which is electrically neutral." It must be borne in mind that these conclusions are drawn by Thomson from the study of one class of phenomena, and it is of course possible that they may not be finally sustained. Their value to us at the present moment lies in their suggestiveness, and in the curious way in which they reinforce other arguments of similar purport. The possibility that the chemical atoms can be

* The Wilde lecture before the Manchester Philosophical Society, delivered May 19, 1903.

† A very full account of these attempts is given in Yenabie's book, "The Development of the Periodic Law." Published at Easton, Pennsylvania, in 1900.

* Phil. Trans., Vol. 171, 1861, p. 1003.

† Phil. Mag. (6), 1, p. 311.

‡ Proc. Roy. Soc. Victoria, Vol. 10, part I, p. 70.

§ Phil. Mag. (6), 5, 206.

* Phil. Trans., 1866. A second part in 1877.

† Phil. Mag. (5), 48, p. 547. Also Popular Science Monthly, August, 1901.

† Evolution

1873.

actually broken down into smaller particles of one and the same kind, is, to say the least, startling, but it cannot be disregarded. The evidence obtained by Thomson is so far as it goes positive, and it is entitled to receive due weight in all discussions of our present problem. It is the first direct testimony that we have been able to obtain, all previous evidence being either negative or circumstantial. It may be misinterpreted, but it is not to be pushed aside.

In direct line with the inferences of Thomson are the results obtained by Rutherford and Soddy in their researches upon radio-activity. Here, again, we have a subject so new that all opinions concerning it must be held open to revision, but, so far as we have yet gone, the evidence seems to point in one way. Rutherford and Soddy* have studied especially the emanations given off by thorium, and conclude that from this element a new body is continually generated, in which the radio-activity steadily decays. This loss of emanative power is in some sort of equilibrium with the rate of its formation. When thorium is "de-emanated," it slowly regains its emanative power. The emanation is a "chemically inert gas, analogous in nature to the members of the argon family." The final conclusion is that radio-activity may be "considered as a manifestation of sub-atomic chemical change." This word "sub-atomic" is one of ominous import. It implies atomic complexity, and it also suggests something more. The property of radio-activity is most strikingly exhibited by the metals radium, thorium, and uranium; and these have the highest atomic weights of any elements known. If the elements are complex, these are the most complex, and therefore, presumably, the most unstable. Are they in the act of breaking down? Is there a degradation of matter comparable with the dissipation of energy? We can ask these questions, but we may have to wait long for a reply. There is, however, another side to the shield, and the universe gives us glimpses of a generative process, an elementary evolution.

The truth or falsity of the nebular hypothesis is still an open question. It is a plausible hypothesis, however, and commands many strong arguments in its favor. We can see the nebulae, and prove them to be clouds of incandescent gas; we can trace a progressive development of suns and systems, and at the end of the series we have the habitable planet upon which we dwell. The nebular hypothesis accounts for the observed condition of things, and is therefore, by most men, regarded as satisfactory. But this is not all of the story. Chemically speaking the nebulae are exceedingly simple in composition; the whiter and hotter stars are a little more complex; then come stars like our sun and finally the finished planets with their many chemical elements and their myriads of compounds. Here again we have evidence bearing upon our problem, evidence which led me, more than thirty years ago, to suggest that the evolution of planets from nebulae had been accompanied by an evolution of the elements themselves. This thought, stated in a reversed form, has since been developed and amplified by Lockyer, and it is doubtless familiar to you all. In the development of the heavenly bodies we seem to see the growth of the elements; do we, in the phenomena of radio-activity, witness their decay? This is a startling, possibly a rash speculation, but it rests upon evidence which must be considered and weighed.

We have, then, various lines of convergent testimony, and there are more which I might have cited, all pointing to the conclusion that the chemical atoms are complex, and that elemental matter, in the last analysis, is not of many kinds. That there is but one fundamental substance is not proved; and yet the probability in favor of such an assumption must be conceded. Assuming it to be true, what then is the nature of the Daltonian atom?

To the chemist, the simplest answer to this question is that furnished by the researches of J. J. Thomson, to which reference has already been made. A cluster of smaller particles or corpuscles satisfies the conditions that chemistry imposes on the problem, their ultimate nature being left out of account. For chemical purposes we need not inquire whether the corpuscles are divisible or indivisible, although for other lines of investigation this question may be pertinent. But no matter how far we may push our analysis, we must always see that something still lies beyond us, and realize that nature has no assignable boundaries. That which philosophers call "the absolute" or "the unconditioned" is forever out of our reach.

Through many theories men have sought to get back a little further. Among these, Lord Kelvin's theory of vortex atoms is perhaps the most conspicuous, and certainly the best known. It presupposes an ideal perfect fluid, continuous, homogeneous and incompressible; portions of this in rotation form the vortex rings, which, when once set in motion by some creative power, move on indestructibly forever. These rings may be single, or linked or knotted together, and they are the material atoms. The assumed permanence of the atom is thus accounted for and given at least a mathematical validity, but we have already seen that the chemical units may not be quite so simple. The ultimate corpuscles, to use J. J. Thomson's words, may be vortex rings; the chemical atom is much more complex. On this theory, chemical union has been explained by supposing that vortices are assembled in rotation about one another, forming groups which are permanent under certain conditions and yet are capable of being broken down. The vortex ring is eternal; its groupings are transitory. This is a plausible and fascinating theory. If only we can imagine the ideal perfect fluid and apply to it the laws of motion; that done, all else follows. Unfortunately, however, the fundamental conception is difficult to grasp and still more difficult to apply. So far, it has done little or nothing for chemistry; it has brought forth no discoveries, nor stimulated chemical research; we can only say that it does not seem to be incompatible with what we think we know. In a certain way it unifies the two opposing conceptions of atomism and plenism, and this may be, after all, its chief merit.

But there are later theories than that of Kelvin,

and some of them are most daring. For instance, Prof. Larmor regards electricity as atomic in its nature, and supposes that there are two kinds of atoms, positive and negative electrons. These electrons are regarded as centers of strain in the ether, and matter is thought to consist of clusters of electrons in orbital motion round one another. Still more recently, Prof. Osborne Reynolds, in his Rede lecture,* has offered us an even more startling solution of our problem. He replaces the conventional ether by a granular medium, generally homogeneous, closely packed, and having a density ten thousand times that of water. Here and there the medium is strained, producing what Reynolds calls "singular surfaces of misfit" between the normally piled grains and their partially displaced neighbors. These surfaces are wave-like in character, and constitute what we recognize as ordinary matter. Where they exist there is a local deficiency of mass, so that matter is less dense than its surroundings; and this, as Reynolds has said, is a complete inversion of the ideas which we now hold. Matter is measured by the absence of the mass which is needed to complete a normal piling of the grains in the medium. In other words, it might be defined as the defect of the universe. The "singular surfaces" already mentioned are molecules, which may cohere, but cannot pass through one another, and they preserve their individuality. Possibly I may misapprehend this theory, for it has been published in a most concise form, and the reasoning upon which it rests is not given in detail. I cannot criticize it, but I may offer some suggestions. If matter consists of waves in a universal medium, how does chemical union take place? Shall we conceive of hydrogen as represented by one set of waves and nitrogen as represented by another, the two differing only in amplitude? If so, when they combine to form ammonia there should be either a superposition of one set upon the other, or else a complex system might be found showing interference phenomena. But would not the latter supposition imply a destruction of matter as matter is defined by theory? Could one such wave coalesce with or neutralize another? To conceive of a union of waves without interference is not easy, but the facts of chemical combination must be taken into account. When we remember that compounds exist containing hundreds of atoms within the molecule, we begin to realize the difficulties which a complete theory of matter must overcome. Chemical and physical evidence must be taken together; neither can solve the problem alone. At present, the simplest conception for the mind to grasp is that of an aggregation of particles. Beyond this all is confusion, and mathematical devices can help us only a little. In speaking thus I assign no limit to the revelations of the future; some theory, now before the world, may prove its right to existence and survive; but none such, as yet, can be taken as definitely established. The theory which stands the test of time will not be a figment of the imagination; it must be an expression of observed realities. But enough of speculation; let me, before I close, say a few words of a more practical character.

Dalton's statue stands in Manchester, a fitting tribute to his fame. But it is something which is finished, something on which no more can be done, something to be seen only by the few. As a local memorial it serves a worthy purpose, but Dalton's true monument is in the set of constants which he discovered, and which are in daily use by all chemists throughout the world. Here is something that is not finished; and here Dalton's memory can be still further honored, by good work, good research, honest efforts to increase our knowledge. We have seen that the atomic weights are the fundamental constants of all exact chemistry, and that they are almost as important also to physics; but the mathematical law which must connect them is still unknown. Every discovery along the line of Dalton's theory is another stone added to his monument, and many such discoveries are yet to be made.

What, now, is needed? First, every atomic weight should be determined with the utmost accuracy, and what Stas did for a few elements ought to be done for all. This work has more than theoretical significance; its practical bearings are many, but it cannot be done to the best advantage along established lines. So far the investigators have been a mob of individuals; they need to be organized into an army. Collective work, co-operative research, is now demanded, and the men who have hitherto toiled separately should learn to pull together. Ten men, working on a common plan, in touch with one another, can accomplish more in a given time than a hundred solitaires. The principles at issue are well understood; the methods of research are well established; but the organizing power has not yet appeared. Shall this be a great institution for research, able to take up the problems which are too large for individuals to handle, or a voluntary co-operation between men who are unselfishly inclined to attempt the work? This question I cannot answer; doubtless it will solve itself in time; but I am sure that a method of collective investigation will be found sooner or later, and that then the advance of exact knowledge will be more rapid than ever before. When the atomic weights are all accurately known, the problem of the nature of the elements will be near its solution. Some of the wealth which chemistry has created might well be expended for this purpose. Who will establish a Dalton laboratory for research, and so give the work which he started a permanent home?

F. W. CLARKE.

HARDNESS OF X-RAY TUBES.—B. Walter has designed a scale of "hardness" or penetrative power of X-ray tubes, which, together with that of Benoist, will, he says, serve as an international and reproducible measuring instrument. The difficulty lies in keeping the measurements free from the influence of current intensity. In his older instrument a lead disk had a number of holes covered with different thicknesses of tinfoil in arithmetical progression and numbered with lead letters. The hardness was determined by the highest number visible by means of the rays as they fell on to a fluorescent screen. The new instrument has the thickness arranged in geometrical progression,

and consisting of platinum foil ranging in thickness from 0.005 to 0.64 mm. The Benoist scale consists of a circular plate with twelve sectors and a central circle, the latter being of silver and the sectors of various thicknesses of aluminium. In measuring the hardness of a tube notice is taken of the sector which is equal in brightness to the silver, the latter having, as we know, the same transmissive power for various hardnesses. The author points out that the two scales mutually supplement each other, the former being more convenient, and the latter more accurate.—B. Walter, Fortsch. der Röntgenstr., VI.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Shoe Polish in Russia.—Shoe blacking and polish are in good demand in Russian markets, where these articles have as yet little competition. As the United States is admittedly the greatest producer of these articles, American manufacturers and exporters should pay more attention to the Russian market.—Simon W. Hanauer, Deputy Consul-General, Frankfort, Germany.

Wire Netting Needed in Portugal.—United States Minister Charles P. Bryan, under date of Lisbon, August 26, 1903, reports to the department, for the benefit of the manufacturers in interest, that Portugal seems to offer an excellent market for doors and window sashes of wire netting, which are unknown in that country. The swarming here of flies, mosquitoes, and other insects nine months of the year would appear to make the demand for such protection universal.

Cadiz a Port of Call.—Consul R. M. Bartleman reports from Cadiz, Spain, August 10, 1903, that the Pacific Steam Navigation Company has decided to make Cadiz a port of call; that from the 1st of October next the service will be every two months; later, a monthly service is to be established. Steamers of the line depart from Liverpool for the east and west coast of South America via Paullac, Corunna, Vigo, Lisbon, Cadiz, and the Cape Verde Islands. The agent of the company at Cadiz is Daniel MacPherson.

Reduction of Duties in Madagascar.—The Official Journal of Madagascar announces a modification of the general tariff of custom dues on certain imports into Madagascar of foreign production, particularly pepper, pimento, tea, and tobacco. This modification implies a reduction of exactly one-half of the duties hitherto charged on these commodities. The modified duties per 100 kilogrammes (220.46 pounds) are as follows: Peppers, pimentos, and teas, \$20.07; tobacco, in leaves or stalks, \$9.65.—William H. Hunt, Consul, Tamatave, Madagascar.

American Fruit in Germany.—The imports of dried, baked, and boiled fruit into Germany for the first half of the present year amounted to 34,070 metric tons (of 2,204.6 pounds each), against 17,757 and 20,067 metric tons, respectively, for the corresponding periods of 1902 and 1901. Of this amount the United States furnished 22,725 metric tons in 1903, against 9,599 and 9,937 metric tons, respectively, in 1902 and 1901. The United States therefore supplied about 67 per cent. of the total imports of such fruit during the first half of this year.—Richard Guenther, Consul-General, Frankfort, Germany.

German vs. American Labor Conditions.—A German economist, Prof. Jastrow, has written an essay in which he deprecates the existing feeling of fear of and dependency on the American banking and industrial market by the investing, commercial, and manufacturing circles of Germany, which, says the professor, gives Germany the appearance of being a dependency of the United States. He augurs a bright future for German industries resulting from the amicable relationship existing between German workmen and their employers, whereas he points to the disastrous consequences threatening American industries from the gigantic strikes and lockouts so frequently occurring in the United States.—Simon W. Hanauer, Deputy Consul-General.

A New Saccharine Plant.—The Technical Review of Berlin states that a plant has recently been found in South America which contains a considerable quantity of saccharine matter, is not fermentable, and possesses an unusually strong saccharine taste. The plant is of the same species as the German Kunigundenkraut (*Eupatorium cannabinum*), is herbaceous, from 8 to 12 inches high. The chemist Bertoni considers this plant as of highly important value from an industrial standpoint on account of its natural sugar properties, which are of a high percentage. Its scientific name is *Eupatorium rebandum*. According to experiments made by the discoverer, the director of the Agricultural Institute at Asuncion, this interesting plant is said to yield a sugar which is from 20 to 30 times as sweet as ordinary cane or beet sugar.—Richard Guenther, Consul-General, Frankfort, Germany.

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Other Reports can be obtained by applying to the Department of Commerce and Labor, Washington, D. C.

* Phil. Mag. (6), 4, pp. 395 and 381.

+ "Evolution and the Spectroscope," Popular Science Monthly, January, 1878.

* On an Inversion of Ideas as to the Structure of the Universe," Cambridge, 1903. The Rede Lecture, delivered June 10, 1903.

THE RENARD DYNAMOMETRIC FAN FOR MEASURING THE POWER OF GASOLINE MOTORS.

At a time when a somewhat animated controversy is taking place as to the selection of a method of classifying motors, and in which some proclaim themselves as partisans of cylinder capacity as a basis of such classification, while others assert that it might be just as well to arrange motors in classes according to their power, it has seemed to us that it would be very interesting to describe the apparatus designed for measuring such power, and employed by Col. Renard, who exhibited them at the Alcohol Congress of last December.

Let us give the words of the report that was read at that time: "The apparatus that we purpose to make known to-day, and which we call a 'dynamometric fan,' has been employed by us for several years past for the study of high-speed motors, electric, explosive, and steam, to the exclusion of the apparatus ordinarily in use—Prony brakes, rope brakes, etc."

"It consists simply of a bar of steel or wood at right angles with the rotary axis of the motor, and to which may be secured a symmetrical couple of planes, generally of aluminium, and moving orthogonally in the air."

"The conditions of resistance of the apparatus may be modified either by varying the spacing of the two planes, that is, their distance from the rotary axis, or by varying the surface of the planes without changing their distance from the said axis. It is the first system that has generally been employed."

"In the type that we have usually employed, the bar is of ash and the planes are of aluminium. Each plane is secured to the bar by two bolts that pass through equidistant holes. There are generally eleven holes in each arm of the bar. In this way it is possible to obtain ten different positions of the plane, positions determined by the number of the hole in which the bolt most distant from the axis is placed. A second group of holes formed in the planes at a half-interval's distance from the first group, permits of obtaining ten intermediate positions."

"The coefficient of resistance of the apparatus thus varies almost continuously."

The mode of construction of the apparatus may be understood from the first two figures. The length of the bar is 4.3 feet, and the weight of the apparatus 26.5 pounds. The apparatus is adapted for the testing of motors making from 600 to 1,300 revolutions and developing from 10 to 80 horse power.

An apparatus of a length of 2 feet, weighing 2.2 pounds, is capable of absorbing at least 20 horse power. These figures prove conclusively that the dynamometric fans are neither cumbersome nor heavy. When the length of the apparatus is not greater than 3 feet, it may be keyed directly to the shaft of the motor. With larger apparatus, it is preferable to mount the fan upon an independent axis running in ball bearings and connected with the driving shaft through a universal joint.

Col. Renard, however, has established scales which, after a simple reading of the revolution counter that gives the speed of the motor, permits of an immediate estimate of its power at that speed.

The fan permits of the continuous registering of the power. If, in fact, we have at our disposal a tachometer or a registering cinemometer, we shall be able in every case to obtain tracings that will directly give the motive power, the fluctuations of which may be easily watched and interpreted.

The entire power is absorbed by the resistance of masses of air that are continuously renewed, since the apparatus operates like a centrifugal fan. There is, therefore, no appreciable heating, and the experi-

ments can be indefinitely prolonged without any surveillance.

If it is a question of regulating the motor, the position of the planes that will give its normal speed will have to be found by experiment, and it will then be possible to adjust the motor while running, and bring it gradually to the highest power which it is capable of developing. Every opportune adjustment will be

followed by an increase in speed. For instance, a motor capable of developing 40 horse power at 1,000 revolutions per minute will, when speeded up to 1,050, have gained 6.5 horse power.

If it is a question of rapidly verifying motors of a uniform type, we shall know in advance what position of the planes corresponds to the best conditions

in which they are nearest together and nearest the axis of the fan.

The calibrating of the fans is effected by means of an apparatus that Col. Renard calls a dynamometric balance, and which he describes as follows: "The apparatus comprises an ordinary scale-beam mounted upon knife edges and provided with two pans, a coun-

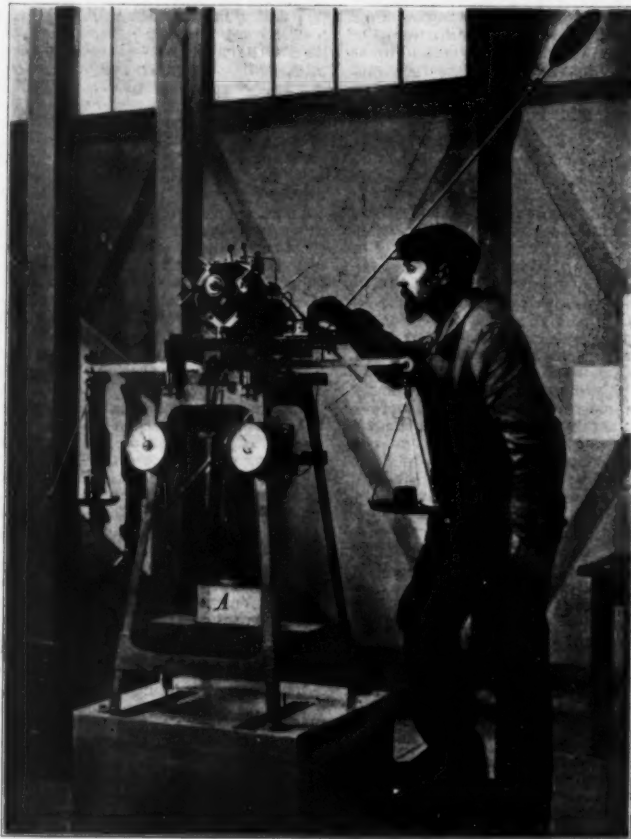


FIG. 1.—THE OPERATION OF MEASURING POWER ABSORBED BY A DYNAMOMETRIC FAN.

terpoise for regulating the sensitiveness of the apparatus, and a registering needle moving over a small dial. This beam supports a frame which oscillates with it and which carries an electric motor that receives its current through two wires plunging into two mercury cups. The following is the nomenclature of the various parts of the apparatus: *B*, frame; *m*, dynamo; *n*, fan; *k*, revolution counter; *f*, levers of the balance; *gg*, conducting wires for the electric current; *a*, registering needle; *c*, dial; *pp'*, weight for balancing; *g*, counterpoise.

The fans to be calibrated are mounted either directly upon the shaft of the dynamo (as in the last two figures, where may be seen a small metallic fan arranged for the calibrating experiment), or upon a parallel shaft permitting of a reduction or acceleration of motion through gearing.

"In order to effect a measurement, we proceed as follows: (1) By means of shot placed in the pans we bring the register needle to zero; and (2) we turn on the current progressively until we have obtained nearly the velocity that we have in view."

"The equilibrium of the balance will be lost. If the fan turns to the right, the entire outfit will tend to turn to the left, and, in order to bring the needle back to zero, it will be necessary to place in the right-hand pan a weight *P*, the moment of which, with respect to the axis of oscillation, is just equal to the resistant moment of the fan in the air."

This method eliminates all friction of the mechanism. It will afterward be very easy to measure this moment. Col. Renard afterward gives the calculations of the limits of use of his apparatus, and demonstrates that the same fan is capable of permitting of the study of a large number of motors having very different characteristics.

It has been proved both by calculation and by experiments that for fans of proportional dimensions throughout, the power coefficient varies as the fifth power of the ratio of linear dimensions. This law has been verified by means of experiments with two instruments, the linear dimensions of which bore to each other the ratio 2.2. The fifth power of 2.2 being equal to 51.54, the coefficient of the larger dynamometer should be equal to that of the smaller one multiplied by 51.54. In spite of inevitable experimental errors and inaccuracies of construction, this relation was found to hold very well for all positions of the disks on the rod.

The law of the fifth power, verified on other apparatus, permits of calculating in advance fans of larger power than it is possible to calibrate with the dynamometer balance. If a number of instruments of the same size is required, it is not at all necessary that all should be calibrated, provided their construction is carried out with reasonable care. Col. Renard possesses a number of dynamometers of the same size, constructed with ordinary care, and experiments have shown that their coefficients vary from each other by less than 1 in 200. With all metal construction, far better results might even be obtained.

The same fan may be used to test motors of widely varying power, owing to the fact that the coefficient varies greatly as the aluminium disks are moved from their innermost to the outermost position on the rod



FIG. 2.—SIDE VIEW OF A FAN MOUNTED ON A SHAFT WITH UNIVERSAL JOINT.



FIG. 3.—FRONT VIEW OF A FAN MOUNTED ON A SHAFT WITH UNIVERSAL JOINT.

A couple of equal planes, therefore, experience a resistance of 37.46 pounds. The work absorbed is the product of such resistance by the velocity, say 1,229.6 foot-pounds, or a little more than 22 horse power.

Let us remark, however, that in the curvilinear motion, the coefficient of resistance of the air is always much greater than in the rectilinear. It is sometimes quadrupled when the planes are placed in the positions

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For the type which has been recognized as the most generally useful, the principal dimensions are expressed as a function of the modulus a (distance between adjacent holes):

- Distance between holes, a .
- Length of rod, $24 a$.
- Thickness of rod, a .
- Width of rod, $2 a$.
- Side of the square disks, $60-11 a$.
- Thickness of disks, $4-55 a$.
- Diameter of bolts, $10-55 a$.
- Diameter of shaft, $40-55 a$.
- Number of holes on each arm of rod, 11.
- Distance from the center to the last hole, $11 a$.
- The limits of power which a dynamometer of this

In addition to the study of motors, to which the dynamometric fans so perfectly lend themselves, other studies will be prosecuted upon the efficiency of the various parts of the carriage. It is possible, in fact, with these apparatus to measure the power disposable on the shaft of the transmission gear, or the differential countershaft, and, finally, upon that of the driving wheel. A progressive study of such parts, establishing the efficiency of each of them, would furnish certain bases of comparison between the different systems now in vogue.

The highly interesting experiments that M. Ringelmann made with endless belts in his laboratory demonstrate the very small efficiency of the transmission parts, and to what extent the power disposable is re-

factors. The use of the apparatus under consideration will certainly be of greater simplicity, and no question of efficiency will intervene to complicate the problem. Moreover, a small number of apparatus will permit of the study of numerous motors, and the installation of a very complete laboratory will thus be realizable without exaggerated cost.

It is thus that the construction of automobile motors becomes more and more scientific. Quite a number of establishments, that of De Dion-Bouton, among others, are beginning to organize admirably-equipped laboratories, with which alone are comparable the laboratories of the great scientific institutions of the United States. In these not only are the materials used for the construction of motors scrupulously studied, but learned researches are made into all questions connected with such construction. A precise estimate of the power of motors, in various conditions of operation, will certainly give valuable data and permit of bringing the explosion motor to its definitive point of perfection.—Translated from *L'Automobile*, with an excerpt from the *Horseless Age*, for the SCIENTIFIC AMERICAN SUPPLEMENT.



FIGS. 4 AND 5.—DYNAMOMETRIC BALANCE FOR CALIBRATING A FAN.

kind may absorb are determined (1) by the limits of speed which the rod will sustain; (2) by the limits of fiber stress in the rod. The first condition demands a limit of circumferential speed of 100 meters (328 feet) per second. This limit has been reached in experiments, but it is possible that the law of the square of the speed still holds good at higher velocities. The fiber tension in the rod, on the other hand, has been limited to 100 kilogrammes per square centimeter (1,420 pounds per square inch), which, with selected ash wood, still leaves a factor of safety of 7 to 8. By combining these two conditions the limits of use of a given dynamometer are easily determined, both as regards angular speed and power.

It is easily demonstrated that all fans of proportional dimensions have the same factor of safety when turning at the same peripheral speed. This equality of safety factors applies not only to the rod, but also to the disks, the bolts and the shaft.

It may surprise that a fan of such restricted dimensions is capable of absorbing so much power. A simple calculation will prove, however, that the result is perfectly in accord with physical laws and generally known experimental observations. At a velocity of 150 feet per second the pressure or resistance of the air is about 50 pounds per square foot; at 300 feet per second it would be four times as great, or 200 pounds per square foot. The disks of a fan 24 inches in diameter would be about 5.5 x 5.5 inches and have a combined surface, together with the rod, of about one-half square foot, so that the pressure on them would be about 100 pounds. The power absorbed at a peripheral speed of 300 feet per second (3,000 revolutions per minute) would be $300 \times 100 \times 60 = 1,800,000$ foot-pounds per minute, or about 55 horse power.

It is stated that fans of the proportions in the table above "have values k which vary from .069 a^2 to 1.018 a^2 , the first of these values corresponding to the rod alone and the other to the disks in the outermost positions." If we understand this correctly, it means that the power absorbed by the fan when running at a peripheral velocity of 100 meters per second, with the disks in the outermost positions, is $P = 1.018 a^2$, a being in centimeters and P in kilogramme-meters per second. This would give for the limit of power for the instrument above referred to, in which $a = 5.5$ centimeters, 5.123 kilogramme-meters per second, or 67.5 horse power.

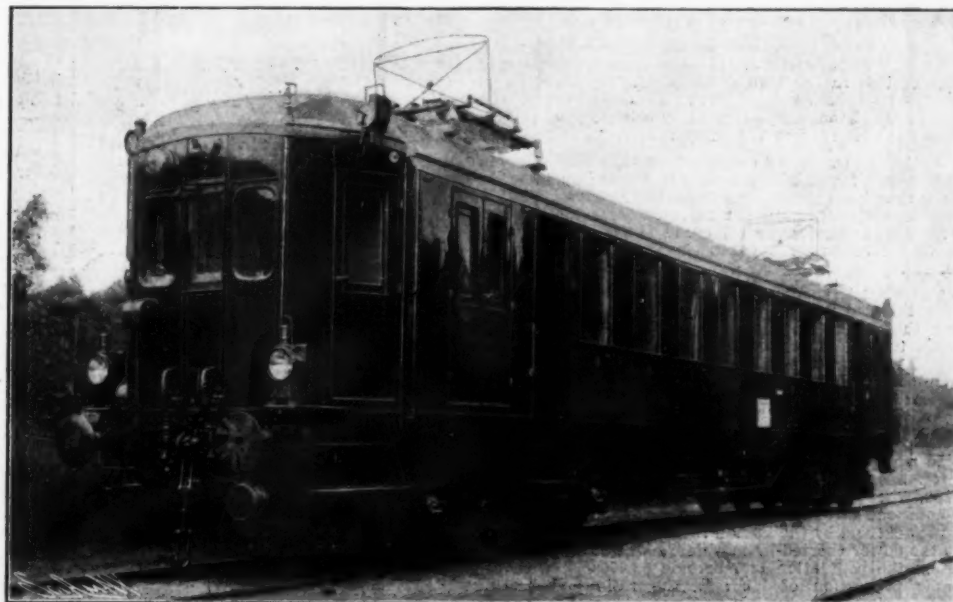
A fan of "modulus" 2 inches should prove very useful for automobile manufacturers. At 1,455 revolutions per minute such a fan with the disk in the outermost position, would absorb 42.62 horse power. The power for other speeds can readily be found by a simple proportion, as the powers at different speeds bear to each other the same relation as the cubes of these speeds. Thus at 750 revolutions per minute this brake would absorb

$$(750 \div 1455)^3 \times 42.62 = 5.85 \text{ horse power.}$$

At the last congress, during the course of a discussion of one of the reports, we heard the president of the technical committee of the Automobile Club announce that some of Col. Renard's measuring apparatus were soon to be installed in the Levallois laboratory. It would perhaps be very interesting to send thither the Criterion motors of $\frac{1}{4}$ horse power. These bicycle motors, used in the "Quarter of a Liter" contest, with an almost uniform cylinder capacity of $\frac{1}{4}$ liter, would certainly show themselves capable of furnishing, some about 2 horse power, and others 3 horse power. This would contribute also toward putting in evidence and causing to be appreciated at their exact value the processes to which the new classification by "cylinder capacity" will lead.

duced at the rim of the wheels. But to obtain a result is not always to apply it, and a more complete analysis becomes obligatory.

We do not think that the technical committee of the Automobile Club of France has considered as yet this special method of verifying motors for classification in races, although we see nothing to prevent it. At present the process of measuring power most employed in factories is that in which the Prony brake is used. It is evidently the most simple one, but is it very accurate? At the moment of braking, it is a delicate matter to ascertain by the tachometer the speed that corresponds to the power measured. Then it has the drawback of not permitting of a continuous study of a phenomenon, nor of immediately making known the improvements introduced into a part, and that, too, during the running of the motor. The study of a motor through a coupled dynamo certainly realizes the solution most capable of satisfying the desiderata that we have just expressed; but this method requires a very delicate gaging of the dynamo and a perfect main-



THE EXPERIMENTAL SINGLE PHASE CAR.

tenance of the conditions of excitation in which the gaging has been done.

One great inconvenience presented by the measurement of the power of motors by dynamos is that, since the conditions of operation of the motor vary very sensibly according to the type and according to the manufacturer, we are obliged, in order to study them, to own several dynamos of different characteristics, so as not to cause them to revolve under too unfavorable conditions from the viewpoint of their efficiency, and to prevent the possibility of too great errors.

The question of the net cost of a laboratory thus constituted, and the incumbrance produced for the needs of numerous experiments, are also important

and fusible plugs. The car carries, in addition, a small transformer which furnishes the current for the air pump, the control and the lighting. There are no starting resistances.

The motors are constructed, after plans of MM. Winter and Eichberg, for a tension of 6,000 volts and 25 periods. They are constantly in parallel. Under full charge, the efficiency is naturally slightly less than that of continuous current motors; but such advantage of continuous current motors is compensated for by the great output of energy at the starting. The tension of 6,000-volts is used only in a part of the ex-

ELECTRIC TRACTION BY MONOPHASE CURRENT.*

By EMILE GUARINI.

THE Union Elektricitaets-Gesellschaft, of Berlin, has just equipped an electric line for the trial of a railway to be furnished to the Société Nationale des Chemins de Fer Vicinal, of Brussels, for the Borinage system. This installation is so much the more interesting in that the current employed is monophasic, which, after having been for a long time discarded, has been taken up again almost everywhere because it seems to give, if not the best, at least a fair solution of the problem of electric traction. The best of all solutions would evidently reside in the use of the continuous current at the highest tension that the insulation of the car could support. This, unfortunately, it is impossible for the collectors to resist. The three-phase current has still other inconveniences, viz.: the speed is difficult to regulate; two conductors are required; the changes of speed cause losses of current, etc. The attempts that have been made to remedy such drawbacks have failed. This explains the reason of the return to the monophasic motor with collectors. The experiments have been resumed by Westinghouse in America and Finzie at Milan. The Union of Berlin has become interested therein, and organized two lines, one of them that already mentioned. This line is supplied with a monophasic current at 40 periods and 600 volts. The experimental car, a type of twenty others that are to be furnished to the Belgian company above mentioned, is provided with two Hochevaux motors. The controller is of the same pattern as those used for the continuous current. The car is arranged for braking in short circuit.

The second line is that of Johannisthal at Spindlersfeld. It is 2.5 miles in length and has but one track, and has been under exploitation for some weeks. At present, a single motor car is running upon it. This weighs, ready for exploitation, 52 tons, six of which consist of the electric equipment. It is provided with two 120-horsepower motors placed upon the same axis, with an excitation apparatus, and, at each extremity, with a controller. It is so arranged that an indeterminate number of similar cars can be coupled and controlled from a single position. The current is taken up by two short arcs. Protection against excesses of current is assured by an automatic circuit breaker

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

citing apparatus and in the stationary part of the motors. In the other parts, the maximum tension is 190 volts, so that all danger to the employees is averted. For lighting, the tension is reduced by a second transformer at 35 volts that permits of putting each lamp in or out of circuit. In spite of the low periodicity, the lamp is free from fluctuations.

The line is equipped with a trolley wire in which the tension of the current is 6,000 volts. The return of the current is effected through the rails. The trolley wire is held at about every three feet by two sustaining wires attached to strong wires extending along the line. At another part of the track there is but one strong wire for sustaining the trolley one. Owing to this arrangement, the breakage of the trolley wire presents less danger than usual.

The monophasic motor of the Union is distinguished from all others by the fact that it is capable of receiving all tensions without preliminary transformation. For the excitation it is only about a sixth of the energy that must be reduced to a lower tension.

There hence results less weight for the car and an improvement in the efficiency. A diminution of the weight is very important for vicinal railways that are obliged to employ reduced means of exploitation if they wish to make their expenses.

Another distinction is established as to periodicity. Other systems employ a periodicity of 16 1/2 or 18, while the Union employs 40. By this fact, all the difficulties in the way of lighting the car disappear. Moreover, there is nothing to prevent the use of a periodicity of 50. That of 40 has been chosen for the Horige system because it is the usual periodicity employed in Belgium. This property is of great importance from the viewpoint of economy, for lines doing a small traffic, because the installation therein of a central station or of special machines would become too costly.

The monophasic system of the Union therefore marks a new progress in electrical engineering. By it the transformer substations disappear, and the cost of the installation of the line is lessened by just so much. The high efficiency of the system allows it to be seen that electric control will soon be employed upon mountain railways with long tunnels, upon city and suburban lines, etc., in which the old system of continuous current with substations and central station with triphased current could not afford sufficient economy to justify the transformation and the new outlay of capital that would have resulted therefrom. It is therefore to be presumed that this new step of the electric industry will give electric traction an extension greater than that which it has already acquired.

ENGINEERING NOTES.

Cape Town has adopted a wood and stone street paving scheme estimated to cost \$10,000,000. The wood required will be imported from Sweden.

The variety of rocks in which quicksilver is found is great, including limestones, sandstones, and shales, many kinds of metamorphic strata, and massive rocks of every type.

No less than 6,535,755 tons of coke were manufactured at the various works in Germany during the seven months ending with July last, as compared with only 5,954,360 tons in the corresponding seven months of 1902.

Recent experiments with the Moissan process for the artificial production of diamonds have shown that crystals of perfect octahedral form and transparency may be obtained by the fusion of a rock similar to the matrix of the South African diamonds. The crystals, however, are only of microscopic size.

At the close of the quarter ended September 30 there were 64 warships of 327,570 tons displacement under construction in the United Kingdom. Of these, 12 of 122,129 tons were being built in royal dockyards, and 52 of 199,450 tons displacement in private yards. Only five of the latter were to foreign orders.

Statistics recently published by the Bulletin de l'Office du Travail of the strikes in France during 1902 show that more than half had for their object to obtain increases of wages; in 111 cases out of a total of 512 strikes this object was attained, in 184 cases there were compromises, and 213 times the strikers were unsuccessful.

The electric roads of the United States carried last year three times the population of the earth. They ran their cars eleven times the distance from the earth to the sun. According to the Iron Age, they killed 1,218 persons and injured 47,429. Their capital was more than twice as great as the bonded debt of the United States, and their gross earnings for a year were nearly a quarter of a billion dollars. They paid over \$13,000,000 in taxes.

In a paper before the Verein Deutscher Ingenieure, Prof. Schmoller, of Berlin University, stated that in 1850, when Germany had a population of 18,000,000, of whom one-half were laborers, the ratio of physical power exerted by the human factor in economic activity to the power exerted by machinery was unity. In 1895, when the population had become 56,000,000, with the same proportion of laborers, the ratio had become one to six, or, according to some authorities, one to ten.

Patches affixed with ordinary rubber solution on the inner tubes of motor car tires to repair punctures have been found to "blow" after use owing to the heat engendered by fast driving. This is due to a defect of the solution with which the patch is applied. This is a solution of crude rubber—not vulcanized—in a solvent such as benzine, toluene, ether, or turpentine. Unvulcanized rubber is very much affected by changes in temperature: it is soft and elastic between 50 deg. and 100 deg. Fah., becomes hard and inflexible below 46 deg., viscous above 212 deg., and melts at 340 deg. Motor car owners will be interested to learn that a French chemist has devised a method of vulcanizing the solution without heat, which is claimed to overcome the difficulty.

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